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Architecture and Landscape Work for the Catskill Water Works.

In these days of advancing culture in the United States, the local governmental authority charged with the construction of a great system of public works has a responsibility other than to make the system as a whole and the structures in detail useful and efficient in a utilitarian way only. With additional thought and skill in design, the visible structures of masonry and earth, with their landscape surroundings, can be made beautiful—a source of pleasure as well as a means for supplying a physical need. Frequently, too, these desirable results can be obtained at slight additional cost, and cases are not unknown in which intelligence properly applied has, in satisfying esthetic demands, secured practical economies. But even if it does cost somewhat more to make public works beautiful, the expenditure, within reasonable limits, is well justified. The older communities, having met their most urgent needs for bare necessaries, can afford such investments for the enjoyment of their citizens. Indeed, judicious expenditures of this sort are not an extravagance, for besides giving wholesome pleasure to the community that builds them, and its neighbors, fine public works may become a source of considerable indirect revenue. Without doubt, several European countries attract their thousands of tourists annually—and take toll from them—not alone because of beautiful scenery, but in part ,by reason of noble and attractive public and semi-public buildings, bridges and other works.

New York City has just entered upon the construction of, probably, the greatest system of water-works ever actually undertaken, and one of the most ambitious engineering enterprises of modern days. These works will bring water a hundred miles or more from the Catskill mountains, across country of unusual scenic charm and much variety of topography. In the valleys of the mountains, where thousands of New York City's residents spend their summer vacations, the impounding reservoirs will be created. Catskill aqueduct will traverse the broad and beautiful valleys of the Esopus, the Wallkill and the Moodna; will pierce the Highands of the Hudson in crossing the main valley of that river, and will continue southward east of the Hudson through the gentler hills and dales of Putnam and Westchester counties, where are many of New York's suburbs and country homes. Along this line are some fifty gatehouses, siphon chambers and other structures suggesting the aqueduct hidden below in trench, or tunnel or embankment. Some of these buildings will occupy most conspicuous sites, commanding in several instances hundreds of square miles of territory. They cannot be concealed; they should be made attractive.

At the terminus of the aqueduct, Hill View reservoir, a covered basin, can readily become a park with broad and pleasing prospects in many directions. Near the large town of White Plains, Kensico reservoir, of approximately 40,000,000,000 gal. capacity, will become an attractive lake of very irregular outline, extending into the valleys among the hills. Its dam, a masonry wall over 2,000 ft. long, on top and 150 ft. high above the surface of the ground, will occupy a site probably more conspicuous than that of any existing large masonry dam, if judged by the number of people who will see it daily. Only 25 miles from the heart of the city, at the terminus of a proposed park system, in the midst of a populous suburban region, it is in full view, at close range, of a railway carrying thousands of persons daily to and from New York. Large aeration plants may also be included in the system, throwing numerous jets of water into the air to considerable height, and there is to be a very extensive filtration plant, which, it is to be desired, may be made more pleasing in appearance than some works of this kind have been.

What opportunities are suggested here, with no light emphasis, for the architect and landscape engineer to co-operate with the water works engineer in creating works which will be the more creditable to all the professions concerned for such a union of technically trained minds! To these opportunities and obligations the Board of Water Supply has evidently not been oblivious. With the good sense displayed in other matters which it has been the pleasure of The Engineering Record to mention the Board has engaged in a consulting capacity for the guidance of its chief engineer and his staff in the design and construction of the visible portions of the works, the services of a landscape engineer and a firm of architects of the highest standing in their respective professions. In selecting these men, it has been stated, not only was care exercised to secure skill of the highest order, but also those qualities of personality which make it possible for men to co-operate. Indeed, but slight acquaintance with the staff of the Board is necessary to convince one that this idea of co-operation is one of the most dominant notes in the policy of the commissioners and the chief engineer. Assistants who have been trained along the lines of architecture and landscape work have been engaged as members of the engineering force, so that the details of all kinds of work may be elaborated and harmonized under the immediate supervision of the chief engineer.

Such excellent results have been achieved in recent years by similar association of architects and landscape engineers with civil engineers, that the wisdom of this most recent endeavor to do something better than the ordinary in the construction of water-works can not be gainsaid. It is to be hoped that the good example of New York and Boston and some other cities will soon become the usual practice, not only for water-works, but for all public works. The recently completed Metropolitan water-works of Boston now give ample justification in their most attractive appearance for judicious regard for the esthetic sensibilities of the community and the slight additional cost which it entailed. With this successful precedent fresh in mind, this journal anticipates with confidence an accomplishment which will be thoroughly creditable to the metropolis and a cause of pride to its citizens, if the men who are now so ably directing the works be allowed to continue untrammelled in their good policies.

Problems of Motor Application.

In view of the amount of engineering attention usually given to the purchase and installation of electric generating equipment, it is singular that problems of motor application are so frequently settled off-hand by owners of industrial plants. The ability of the average well-made motor to withstand abuse is, no doubt, partly responsible for this, and another reason for the quick decisions often made as to the kind of motor selected for a given duty is found in the subdivision of motor units necessary in the great majority of installations, whether individually or group driven. Then there is the question of first cost and delivery, which is naturally important to an establishment working under conditions of forced output.

It is an easy matter in simple problems of motor application to spend more time upon the selection than the case warrants, but in the choice of motor drives where several units are required, there are some fundamental points which should not be overlooked simply because it is about lunch time and because the motor salesman has quoted a good price on standard outfits. The amount of power, average and maximum, which the machine or group to be driven will require; the prospect of more machines being added to the load of each motor; the amount and range of speed regulation necessary; the character of attendance that can be counted on; the weight of the motor unit and cost of special construction to support it, if on a wall or ceiling platform; and the efficiency curves of the motors offered should all be carefully considered. Too few manufacturers are possessed of data showing the percentage of time different machines are idle and the variations in individual power demands at different times.

The question of motor efficiency is of much more importance than is always realized. Motor design has developed to a point where certain efficiencies may be expected in certain types and sizes of machines, but unless a motor is selected to run at or near its normal rated output the greater part of the time, the benefit of a highly efficient design cannot be had, the cost of the motor becomes unduly great for the service rendered, and the cost of power lost in the distributing system and the expense of excess current generation at the prime movers above the normal, tend to defeat its economies, which the electric drive is generally capable of bringing about if properly installed.

Occasional tests made on working installations are found to throw considerable light on the motor situation and guide future decisions as to motor selection. On account of the extremely low maintenance cost of many motors in definite commercial service, there is often an absence of accurate repair records in plants where the most minute details of engine, boiler and generator maintenance are carefully kept. A policy of charging off motor repairs, however, enables the exact cost of the electric drive to be figured in different departments, and the expense of testing the starting current, speed and power consumption of service motors is almost nominal in comparison with the value of the data. Given a motor of large capacity installed in connection with a group drive, it is most essential to find out from time to time whether it is being seriously overloaded or not, either through changes in the operating conditions at the machines or through the addition of more machine units than the motor can properly handle at the maximum rate of production.

No question is of greater importance in the applications of electric motors to commercial service than the group contrasted with the individual drive. It is not the purpose of these comments to discuss the relative advantages of group and direct driving, but to emphasize the need of going into the question thoroughly in practice. Expert advice is more necessary here than in any other phase of the motor problem. Nothing short of a careful estimate of the total annual cost of each method, taking into account the installation and purchase expense, operating efficiency of each combination, flexibility value, probable reliability and repair cost, interdependence of departments, in brief, the total power cost at the motors per unit of manufactured product, will furnish a proper basis for a sound decision in motor selection.

Sheet Piling and Earth Pressure.

There are some puzzling questions which arise in connection with sheet piling as used for both small and large excavations, especially when the latter are of considerable depth. As a matter of fact, the bracing generally employed to hold the sheeting or sheet piling in place is designed more as a matter of judgment than of exact computation. The ordinary rational theory of earth pressure is based upon an assumed perfectly dry material composed of small grains, possessing no coherence among themselves. The standard quality of earth on which is based the usual theories of earth pressure is that of a fine granular mass, whose particles are free to move over each other except for friction, these particles assuming an exterior surface slope, under normal conditions, whose tangent to a horizontal line represents the coefficient of friction. This theory results in an intensity of pressure for a mass of dry earth which increases directly with the depth as does water pressure, but at a different rate. There are few structures whose design involves the use of formulas for earth pressure which have not been proportioned upon this theory if their treatment has been of a rational character; in fact, Rankine's and other similar theories have come to be standard for this entire field of construction. Although these earth pressure theories have been criticised for various alleged defects of more or less serious nature, the latest is probably one of the most interesting attacks of this kind.

In a recent number of the "Proceedings" of the American Society of Civil Engineers, Mr. J. C. Meem has presented a paper on "The Bracing of Trenches and Tunnels, with Practical Formulas for Earth Pressures," the main features of which were stated in The Engineering Record of Nov. 2. In this paper the author has set forth certain views as to earth pressure which are based on his observations in sheeted or sheet-piled trenches. He has observed that in many new excavations both the bottom and the bottom portions of the vertical sides remain stable in place even when not supported, while in the upper parts of the same trenches the material has exhibited such a tendency to motion as to produce heavy pressures against the sustaining sheeting with its braces, the excavated material not being dry sand. He assumes, therefore, in treating the laws of pressure thus disclosed, that the greatest earth pressures are near the top of the excavation, from which place they decrease to the bottom, where they are either actually or essentially zero. This obviously is fundamentally at variance with the ordinarily accepted law of earth pressure, which makes the intensity of that pressure zero at the surface and a maximum at the bottom of an excavation, with a uniform rate of variation between.

The difference between these laws is radical, as is recognized by Mr. Meem himself. If his views are correct, practically the whole body of present and past practice in connection with earth pressures is altogether wrong, except in the case of dry, sandy material, for which he would employ the generally accepted theory of earth pressure, the law of whose variation with the depth below the surface is similar to that of liquid pressure, i. e., the intensity varies directly as the depth.

Probably every experienced engineer who has had much to do with the design and construction of structures to resist earth pressure, has recognized the familiar fact that the standard theories of earth pressure are not supposed to be more than approximately correct for other materials than dry sand. There are, however, with equal probability, very few who would be willing to postulate with emphasis that the intensity of pressure against sheet piling and its bracing decreases with the depth of excavation, becoming zero at the bottom of the latter, and acquiring a maximum value in its upper part. It is true that in almost any excavation other than in dry sand, the material in its bottom stands stiff and undisturbed for a greater or less period of time after the excavation is completed. There is nothing uncommon about that; it is a matter of frequent observation. A damp clayey or loamy material holding considerable moisture assumes under the heavy pressure of the superposed material a stiff, dense and firm condition, which disappears only after weathering, and much weathering in some cases.

If a trench or other excavation is to be quickly completed and refilled, insufficient time may elapse for such material to lose its moisture, and so to become friable or granular behind the sheeting and produce intensities of pressure of relatively high values. This is precisely what takes place in many excavations of magnitude. Material is frequently found capable of maintaining a vertical face for a considerable time even without the support of sheeting, but the instances are rare where such faces will not soon become dry enough to lose coherence and granulate to a marked degree, and slough off or fall away if unsupported, like any dry granular material in which the maximum intensity of pressure is found at or near the bottom of the excavation. Under such circumstances it certainly would not be prudent or safe to rely upon the temporary tenacity thus disclosed to hold long in position the sides of such excavations. It is a matter of common experience to observe the weakening by dessication of vertical earth faces, nor is it so very infrequent to experience the failure of sheeting with its bracing from this kind of a cause. The matter practically reduces itself to taking chances with these excavated faces and hazard reaching the refill before the material with its reduced moisture has an opportunity to assert its capacity for lateral pressure.

More than one instance of this character has resulted in failure. Experience with excavations in general has taught the important lesson that, except in comparatively few cases of unusually tenacious material, it is safer to assume that the relatively dry granular condition may prevail sooner than anticipated, and that in general it is prudent to accept the indications of the standard theories of earth pressure, if there is much at stake. In the more difficult and dangerous saturated or semi-saturated, materials, it takes but little experience to confirm the accepted laws of earth pressure and to realize that such earth pressure theories as that of Rankine are among the valuable technical assets possessed by the engineer.

Notes and Comments.

The Detroit Tunnel Operations described in this journal last week and in previous issues are so novel as to deserve a word of comment. Several projects for constructing subaqueous tunnels have been proposed in which sections of the tunnel are built on ways, launched and towed to the place where they are to be sunk, but in this undertaking the various steps are unique in their conception. The forms are first sunk, then surrounded by concrete placed under water, and finally the forms are pumped out and lined with concrete without the use of compressed air. This procedure was first proposed by Mr. W. J. Wilgus, a fact that was unfortunately not stated in the article printed last week. Mr. Olaf Hoff, of the Butler Bros.-Hoff Co., the contractors, is in personal charge of the work and has elaborated the details in a most ingenious manner in order to carry out the contract successfully.

The Arlberg Ry. Electrification, the most extensive undertaking of this nature now under way, affords an interesting example of the accuracy of some of the general statements in Mr. Armstrong's valuable paper reviewed elsewhere in this issue. This road, a single-track line, is understood to have more business than any other crossing the Tyrolean Alps, about forty trains moving over it daily in each direction. This traffic has congested the line many times annually during recent years and it has become necessary to double-track the road, an enormously expensive undertaking, or to provide means for hauling heavier trains at higher speeds. By adopting electric traction the capacity of the road can be increased 50 per cent. at a far smaller outlay than that for a second track. The consulting engineer for the work is Prof. C. L. de Muralt of the University of Wisconsin, who has selected the three-phase system for this installation, a selection practically forced by the railway authorities' drawbar pull and speed requirements, which make it necessary to develop 3,000-h.-p. with a locomotive weighing not more than 60 tons. The current will be furnished by hydro-electric stations and on the down-grades the motors on the locomotives will act as generators, returning current to the line and saving a large sum otherwise required for power, in addition to reducing heavy wear of brake rigging.

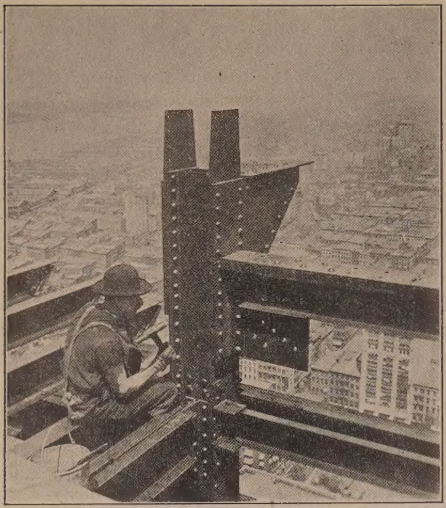
The Enormous Arch of reinforced concrete, with its clear span of 710 ft., which is the central feature of the design for the Henry Hudson memorial bridge at New York prepared by Prof. Wm. H. Burr, is the boldest bridge project for many a year. The designer has been working out the details of the plans for more than a year, assisted by the engineers of the city's Department of Bridges, and the project is now before the Municipal Art Commission for its approval. It goes without saying that the designs will receive critical study by bridge specialists everywhere, for no masonry arch approaching it in span or resembling it in design, save as a miniature resembles a large canvas, has been worked out before. At one step, reinforced concrete construction has been advanced from the very conservative works of the past to a structure that probably represents the maximum limits of practicability of the material. The computations have been conducted with great thoroughness by Mr. Leon S. Moisseiff, of the Department of Bridges, whose analytical ability is widely known, and methods of building the structure have been developed sufficiently to demonstrate their feasibility. Those critics who pronounce a hasty judgment against the design will therefore probably find that their arguments have already been examined during the progress of the studies and have been met satisfactorily.

The Excavation Records which Colonel Goethals and his staff continue to make at Panama are astonishing. The September record was a gratifying achievement, but that of October is a complete surprise. During the month about 1,844,500 cu. yd. of material were taken from the canal prism, an increase of more than 23 per cent. over the record for September. The significant fact of this accomplishment was that during October the rainfall amounted to 17.1 in., as compared with 11.9 in. in September and 11.89 in. in August. In addition to the material taken from the canal prism about 24,300 cu. yd. were removed from accessory works, chiefly the excavation for the big locks. If excavation can be carried on at this rate during a month of such heavy rainfall, what may not be expected during the season when the working conditions are more favorable? That the best excavation records obtained under Mr. Stevens have been increased more than 75 per cent. during the month of the year worst adapted for such work is a pretty good indication of progress. Another thing just as important in one sense is the excellent result of Secretary Bishop's endeavor to do away with all needless causes of discontent on the isthmus. As chairman of the Commission's committee on grievances he hears every complaint and is able to make a thorough investigation of it. By means of the "Canal Record" which is distributed free among all employees whose names are on the "gold" roll, he has accomplished wonders in producing that feeling of common interest and united endeavor essential for the best results where large bodies of men are engaged. The present situation on the isthmus is certainly one in which the American people may take justifiable pride.

The Lack of Balanced Education afforded by courses in engineering colleges is discussed at some length in the recent annual report of President Schurman, of Cornell University. These courses suffer, in his opinion, from being exclusively in the field of mathematics and physical sciences. He believes that the modern engineer, to be truly educated, needs a training broader than science and its applications. He must have the liberal expansion of mind which comes from the study of literature, history and philosophy if he is to attain the highest rank. The problem, however, of teaching all the professional subjects made necessary by the advance of engineering practice necessarily makes the curriculum of the four-year course more and more technical and less place than ever remains for any of the liberal arts. As a result, President Schurman states: "All over the country men are graduating in the engineering courses with an ignorance of literature, history and liberal arts so dense that no proficiency in science and technology can save them from the charge of being uncultured, especially when, as so often happens as a necessary result of their limited reading of literature, they are unable to express themselves either in speech or writing in correct English prose." Consequently a five-year course is suggested as the next step to be taken for improving the education of engineers at Cornell. The extra time gained by the additional year is to be given up to humanitarian subjects, in order that the graduates may receive some measure of real education as distinct from technical training. This will be considered an advance by a good many of the engineers who hold that the next great step in elevating their profession will be in the broader education of those following it. Whether, however, the suggestion of Professor Schurman to add an additional year, and preferably two years, to the present course in order to incorporate liberal arts studies along with those of a technical nature should be preferred to the requirement of a course in the liberal arts in a college as a preparation for technical studies will certainly be a matter of debate. It must be recognized that in the West where technical education is largely conducted in state-aid colleges, the requirements for admission are extremely low in the elements of history, literature and the arts. While the technical instruction in all parts of the country is on a pretty satisfactory plane, the fact remains that the instruction in academic branches as distinct from scientific branches is by no means of such a uniform character. It may be better, therefore, to keep technical training such as is given in a four-year course in an engineering college an entirely distinct thing from the education in a liberal arts course.

Municipal Repair Plants for maintaining asphalt pavements in proper condition have been a subject of considerable controversy for a number of years. For some time this journal believed that the desirability of installing and carrying on such plants was questionable in many cities, particularly those where the management of public works did not rest in the hands of technically trained officials. The experience to date with such plants has been wholly favorable, however. The city of New Orleans is one of the largest which has tried such a plant and in the last report of Captain Hardee, city engineer, the operations for the past year are stated to have been entirely satisfactory. The mechanical equipment is complete in all respects and the stone crusher has furnished a large amount of broken stone for other than pavement purposes. The asphalt machinery has been worked every day during the year except Sundays, holidays and rainy days. During the 141 working days it turned out 88,947 cu. ft. of wearing surface mixture, the largest run in any day being 1,845 cu. ft. There has been no break-down whatever. The sum of $40,307 has been spent for all repairs made to asphalt pavements during the year, while under the old rates the city would have been obliged to pay the Barber Asphalt Paving Co. $114,500 for the same amount of work. The first year's saving due to the plant is, therefore, $8,000 more than the actual cost of the entire installation.

Financial Hysterics, like the recent exhibitions in a few places, are the same strange things seen when a crowded street car bumps good and hard into a substantial truck. Before the motorman and driver are well into their controversy concerning each other's character, ability and future abode, some of the passengers will have shrieked themselves into a frenzy or have fainted away. It isn't their fault and they will be mightly ashamed of themselves afterward; but for a time they make a disturbance all out of proportion to the danger, and everybody who sees them carry on is more or less upset. It is about the same when a policeman grabs a husky pickpocket and clubs him into submission. Some people who don't know what the row is about will vociferously condemn the wanton assault on an inoffensive citizen, while the fellow whose pocket was picked will be equally mad because he has to go to the station house to get his things back. A few weeks ago some of our good financial policeman fired out of several New York banks a few men whose absence from banking circles was considered desirable. The usual crowd collected at the noise of the row and started all sorts of baseless rumors. To cap the performance, a fool newspaper reported the next day that there was trouble in a great, sound financial institution. Immediately there were hysterics; a silly, reasonless exhibition just like the ladylike variety we all regard with pity. It has scared a good many timid souls through the country, however, but perhaps, after all, it was a good thing it happened. A few of us will have our money tied up for a time in suspended banks, but we will get it out again before long. In the interim we will learn to be a little careful of our pennies, which will do no harm. For some months brash persons will not have the means to rush headlong into big enterprises which cannot stand careful investigation, and some manufacturers may have to hunt around a bit for orders instead of selecting at leisure the best of the host urgently thrust into their hands. The trouble will be repaid if Congress will take the lesson of recent events to heart, as it seems likely to do, and repair our currency system. Such a wretchedly inadequate system would long ago have brought on a slow fatal decline if the basis of our national prosperity was not so vigorous that even this powerful irritant could do no more than produce an occasional itch. The present system is just about as elastic as a dry mud pie, and not much more useful. It now appears probable that this makeshift will be supplanted very soon by something as good in its results as the systems of Great Britain and France. The trouble we have had the last few weeks has been due mainly to lack of currency, and that was caused by the inability of our rigid banking law to render any help when a few men went crazy, shouted "thief," and scared timid people into the foolish belief that their money was safer under their pillows than in the banks. The bankers in a few cities have had a hard time with their frightened depositors, but if Congress will attend to its part of the job and the people at large will refuse to get scared when hysterical persons yell "ruin," this disturbance will be cured in short order.



A Column Connection.

The Structural Features of the Singer Building, New York.

The general interest aroused in the Singer Building by the widespread stories of the work of a steeple-jack on the top of its lofty flagstaff makes it desirable to bring together the leading facts concerning its structural features, already described in detail in many articles in previous issues of this journal. The building, at the corner of Liberty St. and Broadway, covers an area of about 24,000 sq. ft., with a main structure having a uniform height of fourteen stories, surmounted by a large tower 612 ft. in extreme height above the curb. It includes the old steel frame Singer and Bourne Buildings originally ten and fourteen stories high respectively, and their additions and extensions which have been combined into a single continuous structure with fronts of about 133 ft. on Broadway and 238 ft. on Liberty St. The old Bourne Building and the old Singer Building have grillage foundations on sand, the Bourne Building addition has reinforced concrete spread footings, and the addition to the Singer Building and its great tower have concrete pier foundations carried down by the pneumatic caisson process to rock at a maximum depth of about 92 ft. below the Broadway curb.

The building is of fireproof steel cage construction of the ordinary type, except that special provision is made to resist wind pressure in the tower. It is designed for office purposes and has a two-story curved mansard roof and flat deck corresponding with that of the old Singer Building. The tower, 63 ft. square at the base, has vertical walls faced with brick and limestone. It is located near the centre of the Singer extension with the front wall parallel to Broadway and about 30 ft. back from the curb line, so that the main building has the effect of a wide base about 200 ft. high for the tower shaft. The tower contains thirty-three principal stories above the main roof, making forty-seven stories in all, and terminates in a segmental dome springing from the thirty-eighth story and finished with a flat deck at the forty-second floor, carrying a lantern about 16 ft. square and 63½ ft. high, with a steel flag-pole rising nearly 36 ft. above it. The highest office floor is the fortieth, at an elevation of 524 ft. above the curb, and the lantern balcony, 562 ft. above the curb, is the highest point accessible to the public, while the summit of the small dome is 612 ft. and the top of the flag-pole is 668 ft. above the curb.

The numbering of floors adopted in this article differs somewhat from that used in the previous articles. On the architect's plans two stories, known as the ground story and messanine story, are not numbered, therefore what is called, on the architect's plans, the first story is in reality the second story. The mezzanine story, between the thirteenth and fourteenth stories, was not numbered, so that in the present numeration the story originally designated as the fourteenth becomes the sixteenth, and all stories above it are correspondingly changed from the former designation, numerals commencing at ground level.

The structural features correspond with recent practice for steel cage office buildings and are most interesting in the provisions for wind bracing required for the 30-lb. horizontal pressure assumed on the entire vertical surface of the building. There are 58 lines of steel columns with closed rectangular cross-sections, which support the beams and girders of the various tiers on horizontal connection angles field-riveted to their top and bottom flanges. In the fourth story one of the corner columns is carried on a triple web cantilever plate girder 30 in. deep and 18 ft. long, which receives a load of about 500,000 lb. and is anchored by bearings on the under side of brackets riveted to one of the interior columns. The columns have cast-steel bases distributing their loads over I-beam grillages covering the tops of the concrete piers. Tower columns have maximum combined loads of as much as 1,637 tons and have correspondingly massive lower story sections.

The heavy wind pressure is resisted by a system of 25 vertical panels of X-bracing between adjacent pairs of columns. Four panels terminate at the sixteenth story, sixteen panels in the corners of the tower are carried up to the thirty-fourth story, and the remaining five panels, between the interior columns of the tower, are carried up to the thirty-eighth story. In nearly all cases the wind bracing consists of full-length intersecting diagonals in each panel. All of the horizontal members are made of pairs of channels back to back, and the same construction is used for the diagonal members except in the highest stories, where the strains are lighter and single channels or angles are used instead. Some of the wind-braced panels are replaced in the lower stories with knee-braces instead of full-length diagonals. In the tower, the X-braces are arranged in alternate long and short vertical panels to clear the door and window openings.

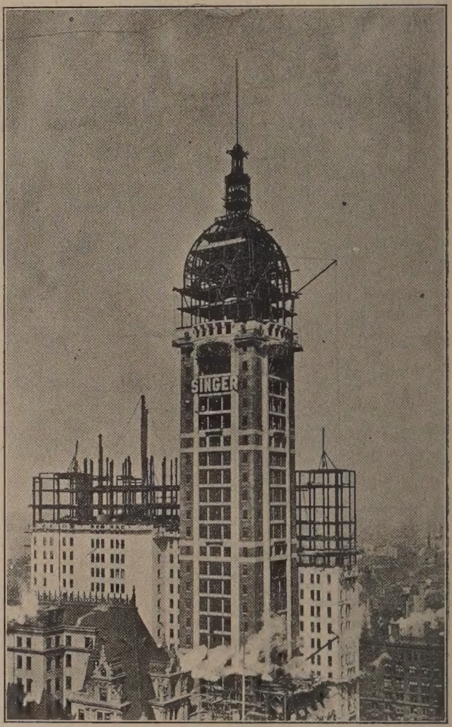
In all cases the wind braces are field-riveted to wide projecting connection plates shop-riveted to the columns. In many cases these occur on three faces of the same columns, making them extremely bulky and difficult to store or handle. The tower has 36 columns continuous through the fourteen-story building to a point 320 ft. above its roof at the foot of the dome 510 ft. above the curb.

The four center columns are continuous to the forty-fifth story about 580 ft. above the curb, where they support the light framework of the upper dome about 30 ft. higher. They have a total length of 579½ ft. each and a cross-section of 160 sq. in. at the bottom, while the others are only 499 ft. high, but have about the same cross-section. Eight of them are anchored with four 4½-in. vertical screw rods engaging pin-connected riveted links extending through the pier 40 or 50 ft. to its base, where they are secured to anchors cast into the concrete so as to develop the full weight of the pier, estimated at about 1,150,000 lb., and the enormous earth friction on its vertical sides to resist the maximum upward reaction of about 925,000 lb. developed by the overturning moment of the wind as described in The Engineering Record of May 4.

The four-story dome, 63 ft. in diameter at the base and 50 ft. high, has four hip rafters at the corner columns. Each of them is double and each part is made of a pair of curved 15-in. channels riveted together back to back. They are seated on diagonal beams in the thirty-eighth floor, and rise nearly vertical to the thirty-ninth floor, above which they curve inward to the forty-second floor, having gusset plate connections riveted between their webs for each floorbeam. They are made in two sections, field-spliced in the thirty-ninth story and connected at the fortieth and forty-second to cantilever floorbeams projecting beyond the four centre columns of the tower. In each face of the tower there are four intermediate curved jack rafters similar to the hip rafters between them.

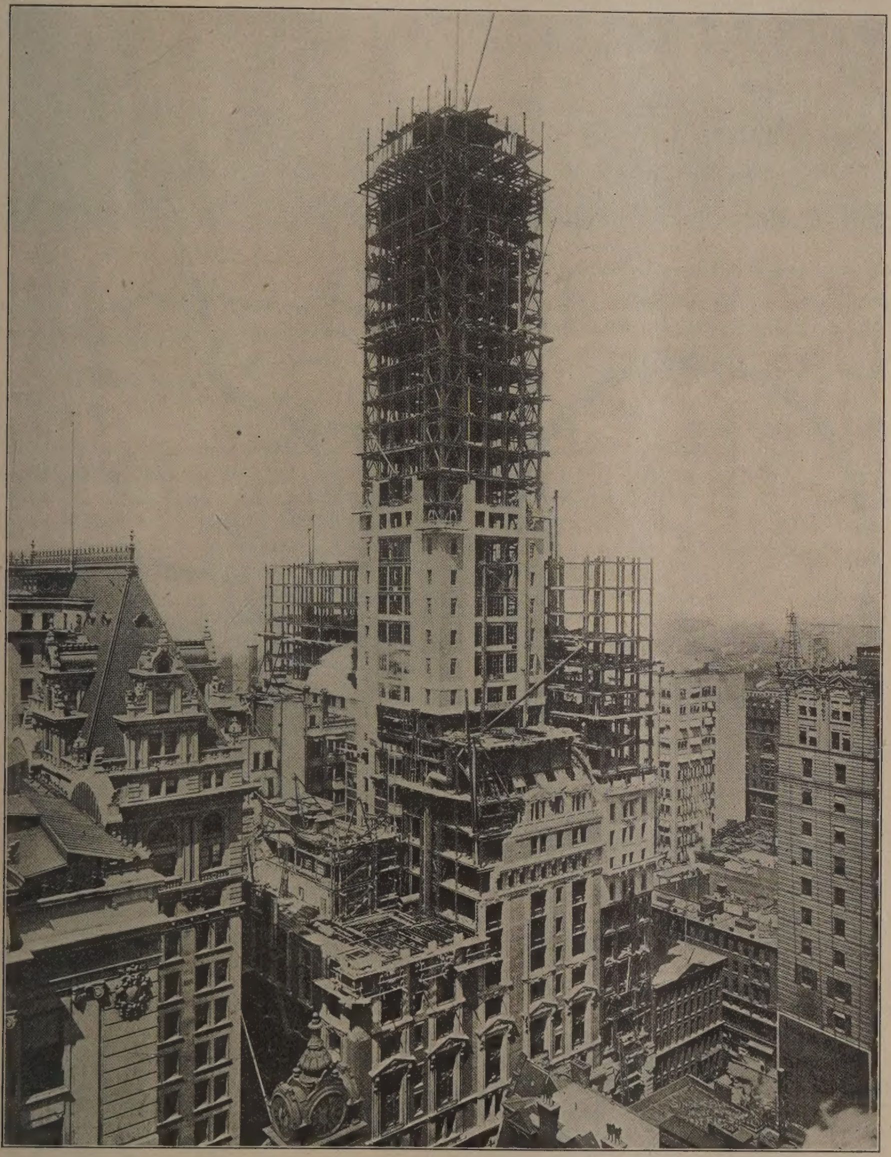
The contract for the sub-structure was awarded September 18, 1906, and required that it should be completed ready to receive the steel superstructure in 110 calendar days. As soon as the old buildings were demolished, a timber platform 30 ft. wide was built on falsework bents from the Broadway front through the center of the lot nearly to the rear, and served for loading and unloading materials. It was provided near the middle with a two-story tower 28 ft. high, with clearance underneath for wagons, and had a 30-ft. steel extension with a 60-ft. 15-ton wooden boom at each corner commanding the entire area of the lot.

Wooden caissons of a maximum weight of 12 tons were delivered complete by wagons from the contractor's yard and were unloaded and set in place by the derrick booms, and the concrete piers were built like tall vertical shafts on their decks, before sinking was commenced, thus saving cofferdams and providing a great weight for forcing them into the excavation made later by men working under pneumatic pressure in the usual way. In this way, the thirty caissons were sunk a little below the surface of the hard pan and the excavation continued below them to rock for the concrete filling. The work was carried on continuously by two 150-men shifts in charge of Mr. Alexander Allaire, superintendent for the Foundation Company, contractors.



Completed Tower Framework.

All of the structural steel was fabricated at the Milliken bridge shop, Staten Island, and shipped on lighters to pier No. 11 in the East River, where it was delivered on trucks to the Broadway front of the building and immediateily unloaded by means of a derrick seated at first at street level and afterwards moved up with the steel work every second tier. The derrick was of special construction designed by the contractors and had a 75-ft. mast and a 65-ft. boom of 40 tons capacity. Both mast and boom were round sticks of timber with cast-steel and forged steel fittings, and the mast was provided with connections for sixteen 1¼-in. steel guy ropes, only eight of which were used for this work. It weighed 10 tons and was equipped with ¾-in. wire-rope tackles for the hoisting and topping lifts which were rove with from nine to three parts, diminishing as the work advanced and the weight of the members decreased. The derrick was hoisted from story to story in the usual manner, first unshipping the boom and using it as a gin pole on the second floor to hoist the mast with. The entire operation required only about three hours and was accomplished by the regular force of erectors.



View of Singer Building Tower during Erection.

The steel was either assembled in final position as unloaded or was temporarily stored on the highest tier of beams until the columns and girders could be set. Occasionally bundles of small light pieces were temporarily stored on the bridge over the sidewalk. The heaviest member lifted was a 54-ft. section of one of the columns, which weighed 28 tons. All pieces were handled with chain slings. The main part of the building was erected at the rate of about two 250-ton tiers per week, and was completed up to the fourteenth story about June 1st with a maximum force of 200 men. The work was then practically suspended for nearly six weeks, and when resumed the tower was erected at the rate of four tiers in seven days, the heaviest tier weighing about 140 tons.

The erection of the tower was commenced at the seventeenth floor about the middle of July, and was completed Sept. 15th, about 2,000 tons of steel having been raised from 200 to 600 ft. during that interval. This part of the work was considerably delayed by the narrow width of the panels, which made it almost impossible to store more than one of the bulky column sections in each space, and by the awkward location of the column splices which, in order to clear the wide connection plates for the wind bracing, were placed almost midway between the floors and required the construction of scaffolds for field riveting.

After the completion of the main building up to and including the seventeenth floor, which serves as a roof deck, some of the wall columns in the Broadway front were continued from the fourteenth floor, where they terminated and the curved mansard roof rafters commenced, to the seventeenth floor at the level of the main flat roof by temporary steel columns braced in position. These carried steel girders and heavy wooden beams and planks forming a deck at the seventeenth floor level, which extended over the curved mansard roof and provided a substantial landing platform for the steel members used in the tower.

The 40-ton boom derrick was seated at this point and hoisted all steel members from trucks on Broadway, deposited them on the platform or delivered them directly to a similar derrick of 25-tons capacity that was carried up in the usual manner with the successive tiers of beams in the tower and erected the entire framework of the latter. Being located in the center of the tower the derrick mast was about 60 ft. from the Broadway front of the building and its boom was not long enough to command the trucks in the street below, hence material was hoisted at two operations as already described.

The 40-ton derrick hoisted from the street to the seventeenth floor, a little over 200 ft., in about 1½ minutes and was operated by a Lidgerwood engine permanently located on the first floor. The 25-ton derrick was operated by another Lidgerwood engine seated on the seventeenth floor and provided with steam from the boiler for their compressors. It had a maximum record of unloading and hoisting 400 tons of steel in 6 hours. The hoisting tackle for this derrick was rove with a spliced ¾-in. steel wire rope 2,500 ft. long and the lower block was provided with a 1,500-lb. cast-iron counterweight to assist it in overhauling. In its highest position on the fortieth floor, it hoisted materials from the landing platform on the seventeenth floor about 350 ft. in 3 minutes. It was moved up with every second tier of beams in the usual manner and was only out of service about 1½ or 2 hours for each operation. Each hoisting engine was provided with two gongs operated by electric buttons at their derricks, signals from which controlled all of the hoisting.

The sixteen columns in the tower were erected like those in the main building up to the base of the dome, above which the four center columns were first erected, together with their beams and girders, by the derrick seated on the thirty-eighth floor. The lower halves of all the curved dome rafters were then set in position and connected to the floor-beams and girders, bracing them with sufficient stability to maintain them until after the derrick was raised to the fortieth floor and erected the next section of the four center columns. The upper parts of the double hip rafters were then erected and their upper ends connected to the column framework of the tower, after which the intermediate jack rafters were erected, the first ones having their upper ends guyed until final connections could be made completing the framework of the dome. The derrick was not moved above the fortieth floor and in that position it erected all of the steel up to the forty-fourth floor, which is the second in the lantern and is about 47 ft. above the fortieth floor. The three last floors and the small dome extend to a total height of about 36 ft. more, and are composed of such light members that they were easily handled by breast derricks with windlasses raised by hand to the successive tiers.

Considerable delay and difficulty were experienced in the erection of the tower, dome and lantern on account of the narrow horizontal area for working and the consequent necessity of keeping the boom derrick topped up in an almost vertical position. Very great pains were taken here, as in the erection of the framework of the main building, to preserve the verticality of all columns as accurately as possible. This was accomplished by the liberal use of large numbers of wire-rope diagonals in the vertical panels between columns and floorbeams. As soon as it was erected, each column was carefully plumbed and if found at all out of vertical one, two or three diagonals were immediately attached to its upper end and adjusted by means of turnbuckles which maintained it rigidly in position until its splices and brace connections were riveted. This method was so successful that when the framework was completed to the full height of 612 ft. above the curb, the greatest deviation of the vertical columns in the elevator shaft was only ⅜ in.

There are about 220,000 field rivets, ¾ in. and ⅞ in. in diameter, which were driven with twelve pneumatic hammers of the Chicago, Independent and Cleveland types. Air was compressed by two Ingersoll-Sergeant machines on the first floor which delivered through a 2½-in. vertical stand-pipe run to the top of the building and was provided with 2½-in. horizontal branches having ¾-in. outlets for numerous flexible hose connections at every story. Great pains were taken in fitting up, and all imperfect holes were reamed with Chicago Little Giant reamers, seven of which were provided for this job. The rivets were heated in oil furnaces provided with compressed air blast and were driven by five to nine five-men gangs who made a maximum record of 1,300 rivets in 8 hours for one gang and 2,450 rivets in 8 hours for two gangs.

The erection of the steelwork is now practically completed and the rigidity of the 6,000-ton mass is so great that no vibration has been observed by the workmen at the summit of the slender tower nearly 650 ft. above the column bases. The rapidity and efficiency of the steel erection has been largely due to the careful preparation made for receiving and handling the steel in exactly the required order and in erecting it without rehandling, the different members being swung complete to place in proper sequence without hesitation and the connections immediately made by men who were well-trained and competent to carry on the work with confidence and precision, wasting no unnecessary time and completing each operation in readiness for the next.

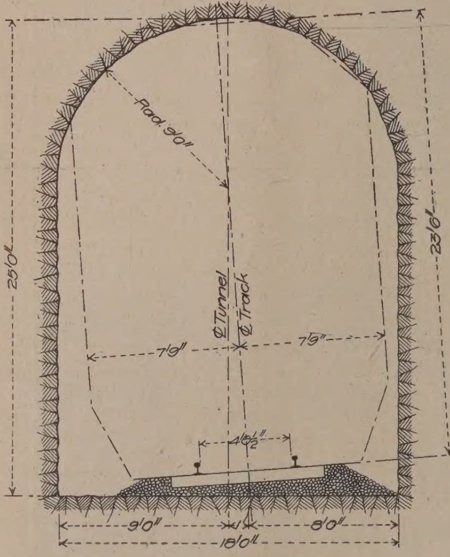
Great care was taken to maintain a constant rigid inspection of the work and of the condition of the building so that the scaffolds were always safe, the derricks in good order and no tools or materials insecurely placed or allowed to fall on the workmen below. Consideration was also had for the comfort as well as the safety of the workmen and a temporary electric passenger elevator was installed at the commencement of the work, as explained in a recent article in this journal, and its guides were extended as fast as the framework was erected especially to provide accommodations for the workmen, who were carried up and down in it to the rapidly increasing height of the building and thus saved much time and labor which would otherwise have been wasted in climbing ladders or stairs.

The steel erection is now practically completed and is entitled to the enviable distinction of two records, one for the great rapidity of construction and successful completion of a framework nearly double the height of any previous steel building, and the other for the execution of the lofty and difficult work without loss of life or a single serious accident, results which are most creditable to Mr. W. R. Waterbury, general superintendent of the steel erection for the contractors, and Mr. W. Craig, superintendent in charge.

The construction of the walls, floors, ceilings, partitions and the installation of the equipment followed as rapidly as possible after the erection of the steel work and was well advanced in the lower part of the building before the last of the many tiers of steel were in position. Heavy decks of the ordinary type were built over the Broadway and Liberty St. sidewalks and were used chiefly for storing stone and other material and for the occasional temporary accommodation of light pieces of steelwork. Underneath them elevated bridges were built to carry pedestrians while work was in progress for the vaults and sidewalks below, and two wide entrances were arranged to the interior of the building so that trucks could drive in, make a circuit and return continuously through the other as an exit without interfering.

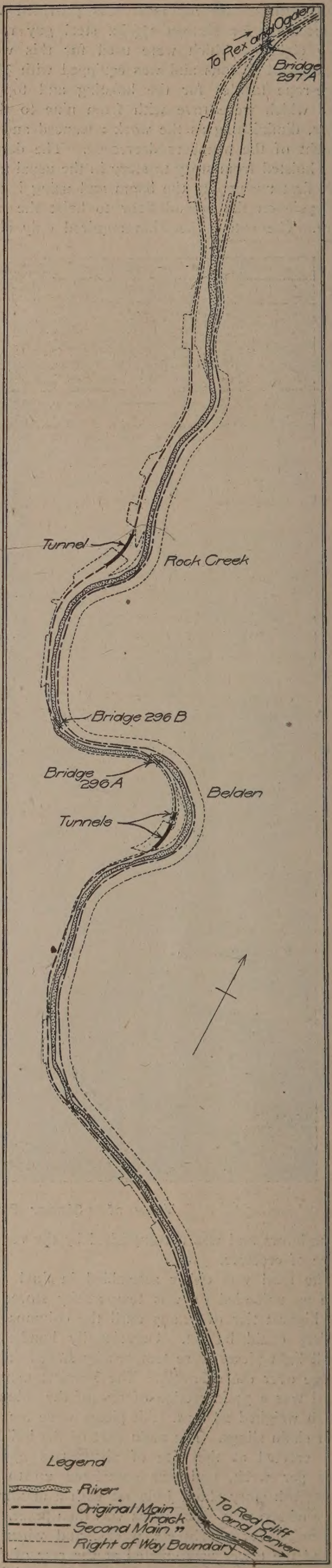
All materials for interior construction were delivered by trucks which unloaded them inside the building, where a portion of the cement, fireproofing and other supplies was stored on the first and basement floors, but the greater part was immediately hoisted by four hod elevators to the stories where it was required. Floor construction was commenced April 15 and was carried on almost as rapidly as the steel erection, being maintained two or three tiers below the latter. All floors are made with National Fire Proofing Company's hollow tile flat arches and had Crown finish dispensing entirely with wood. Brick laying was commenced April 15th by John F. Brady & Co., and stonework for the exterior walls of the main building was commenced May 1st and for the tower August 25th. Exterior Kavanagh suspended scaffolds operated by the masons were used and all of the stone work was anchored by galvanized iron bars.

The trim is all pressed steel and the doors, window frames and sash are kalamined copper thus eliminating all woodwork except in portions of the old building. The windows in the court and up to the twentieth story of the tower are glazed with wire glass and all structural steel is protected by concrete or terra-cotta covering. The top of the building is waterproofed by the Hydrex Felt & Engineering Co. All construction was supervised directly by the architect's office, no general contracts being awarded. Mr. Ernest Flagg is the architect of the building; Mr. O. F. Semsch, of his staff, chief engineer; Mr. Frank P. Whiting, general superintendent; Messrs. E. A. Rogers, H. J. Howell, and C. S. Heney, superintendents of the various sections. Messrs. Boller & Hodge are the consulting engineers for the structural iron, and Mr. Chas. G. Armstrong for the mechanical plant; R. W. Hunt & Co., inspectors of the structural iron; E. Kennard Thompson, inspector of foundation caissons.

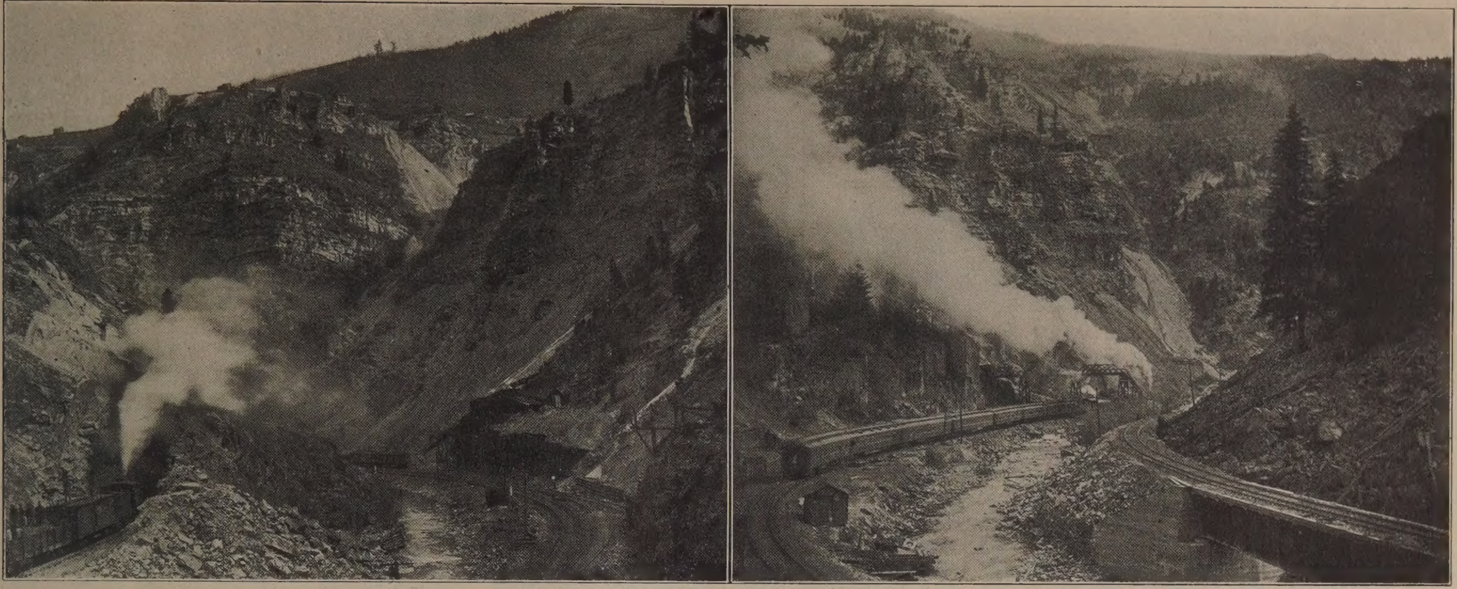


Standard Tunnel Section, Eagle River Canyon, Denver & Rio Grande R. R.

Peat-Coke Manufacture by the Ziegler process has recently been started at Beuerberg, Bavaria. The peat is cut up, pressed and exposed to the air until evaporation has reduced its water to less than 25 per cent. of the whole mass. This peat is then placed in a retort for 18 hours. The coke is finally received in air-tight iron cars which are left for 6 to 8 hours to cool before they are discharged. Each retort yields during every 24 hours 8 to 10 tons of coke. The gas is passed through various tanks and towers in which the by-products are separated, and is then employed in assisting the retort process which could not even commence without the external application of heat.



Tracks in Eagle River Canyon.



Views in the Canyon Looking toward Belden from the East and the West.

Double-Track Work Through Eagle River Canyon, Denver & Rio Grande R. R.

The main line of the Denver & Rio Grande R. R. reaches the crest of the continent on the east by closely following the course of the Arkansas River from Pueblo to the headwaters of the Tennessee Fork. The main range of the Rocky Mountains is pierced at Tennessee Pass by a tunnel 2,572 ft. in length, the elevation of the highest point reached by the track being 10,239 ft. above sea level. On the Pacific slope the line follows the course of the Eagle River from its head to a confluence with the Grand River, thence down the canyon of the Grand to the mouth of the Gunnison River at Grand Junction.

The maximum rate of grade on the eastern slope is 1.42 per cent., which is also the ruling gradient between Pueblo and Tennessee Pass. The descent on the western slope is accomplished by the use of 3 per cent. gradients between Tennessee Pass and Minturn, a distance of 21 miles. West of Minturn the ruling gradient is 1.33 per cent. opposed to east-bound traffic between Glenwood Springs and Minturn, the gradient in control between Grand Junction and Glenwood Springs being 1 per cent.

Salida is a division terminal where are effected complete changes of locomotives, engine crews and train crews in both freight and passenger service. Minturn is a terminal for locomotives, engine crews and train crews in freight service, and for locomotives and engine crews in passenger service. Thus the portion of the main line between Salida and Minturn is an engine district for both freight and passenger service.

The short stretch of 3 per cent. grades between Minturn and Tennessee Pass necessitates the use of a large number of helper engines. The home of these helpers is at Minturn, to which point they return light after a trip to Tennessee Pass. This condition tends towards a congestion of traffic on the 21 miles of 3 per cent. grades, and on account of the rapid growth of both freight and passenger business, it has been found imperative to construct a second main track over a portion of the distance.

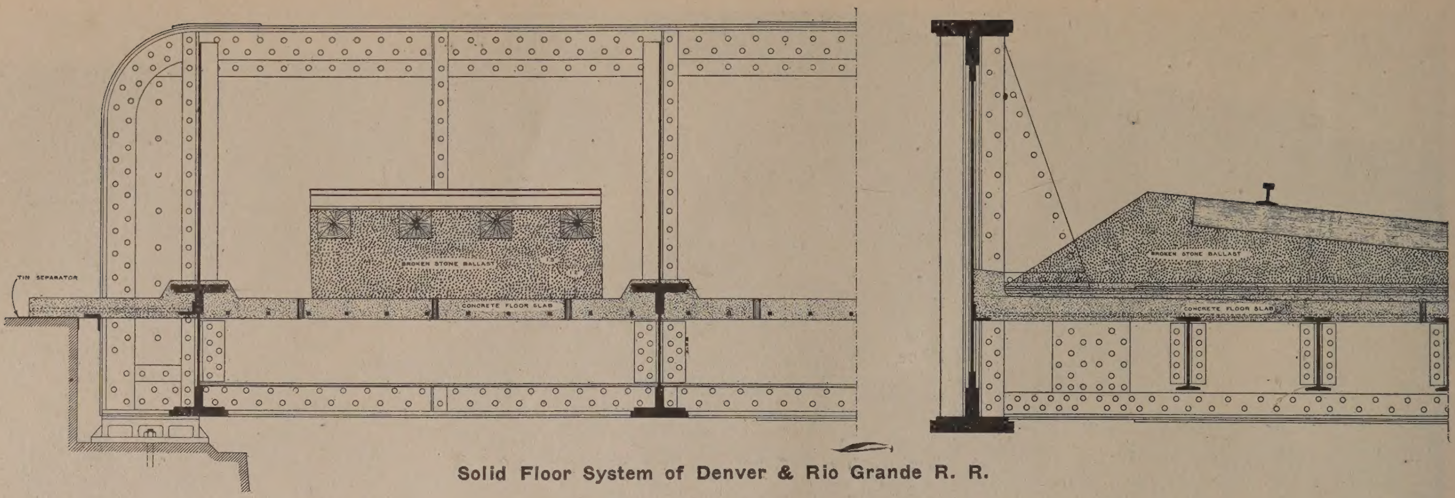
To facilitate the rapid dispatch of trains entering and leaving freight terminals the policy adopted some years ago was to construct double track for a short distance on either side and through the yards of such terminals. Hence in considering the matter of double-tracking a portion of the 3 per cent. gradient it was deemed expedient to extend the second track eastward from Rex, the easterly end of the existing double-track through the Minturn terminals, to Red Cliff, a distance of 5 miles. Perhaps, because of the peculiar topography of the country and the unusual physical characteristics of this portion of the line, a more difficult piece of double tracking could not have been undertaken.

In this portion of its course, Eagle River flows through a very narrow and sinuous canyon, in fact so narrow that it was found impracticable to parallel the old with the new track. Further complications in the existing congested condition of the canyon are occasioned by numerous patented lode and placer mining claims, a number of which are operated to a considerable extent. Accordingly it was deemed expedient to locate the line, for a greater portion of its length, on the opposite side of the river from the present track. In order not to exceed 10 deg. as the maximum curvature, five river crossings and three short tunnels were necessary in the 5 miles of line, but in this distance only three of the maximum curves were used. The tunnels and all of the bridges, except one, are on curves. The maximum gradient on the old track is 3 per cent., but this rate of grade not being continuous over the entire distance, it was therefore possible to use a maximum gradient of 2.3 per cent. on the new track. This reduction, though slight, is of especial benefit since the new track is for east-bound or up-hill trains.

As is usual in mining districts the right-of-way matters were somewhat complicated. The

Retaining Wall at Belden.

Track Location at Rock Creek.



Solid Floor System of Denver & Rio Grande R. R.

numerous claims with their surface improvements, tunnels and waste dumps necessitated rather tedious and laborious negotiations on the part of the railroad right-of-way agents. In some instances it was found advisable to construct retaining walls on the river side of the roadbed in order to provide ground space for mining operations.

The grading was performed by local Colorado contractors. An air compressing plant was installed at Belden, midway between the extreme ends of the work. From this plant compressed air was piped both ways to furnish power for the operation of air drills, which were used both in the tunnels and in the open cuts. The classification of pay quantities was as follows: Embankment, 135,220 cu. yd.; loose rock excavation, 115,315 cu. yd.; solid rock excavation, 153,705 cu. yd.; rip-rap, 2,670 cu. yd.; retaining wall, 6,190 cu. yd.; tunnel, 760 lin. ft.

The tunnels were all driven through solid rock without timbering or other lining, and are notable because of the large section, 18 x 25 ft. This large section was adopted in order to conform closely to the Denver & Rio Grande standard clearance diagram for steel bridges. Because so large a portion of the entire grading quantities consisted of rock excavation, the work was carried on through the winter months without serious inconvenience. Extreme vigilance in putting off blasts was necessary on account of the multitude of trains passing in such close proximity to the work, and the contractors are to be commended for the able manner in which the work of grading was conducted.

For the smaller drainage openings under the roadbed, cast-iron pipe and reinforced concrete box culverts were used. The river crossings necessitated one double track 48-ft. through girder, two single track 80-ft. through girders, and two single track 80-ft. deck girders. One span, an 80-ft. deck girder, occurs on tangent. All the remaining bridges are situated on heavy curvature.

The abutments were all constructed of plain concrete masonry, and, owing to the geological formation, no trouble was experienced with foundations.

The girders were designed for a reinforced concrete floor slab and track ballast, in conformity with Denver and Rio Grande Specifications for Steel Bridges, and as a result they are somewhat notable on account of their great weight. The ballast used is of the best quality of broken stone, and unusual care was exercised in order to secure a desirable character of concrete in the floor slabs.

Field riveting on bridges was accomplished by air power furnished from a flat car fitted up with a steam-driven air plant. The construction of concrete abutments and all other field work pertaining to the bridges and culverts was performed by company forces.

Denver & Rio Grande standard 85-lb. section rails 33 ft. long with plain four-bolt angle bars and flat bottom tie plates were used in laying the track. In order to easily secure a proper and uniform amount of space at the joints for variations in temperature the track was laid from Rex easterly or "up hill."

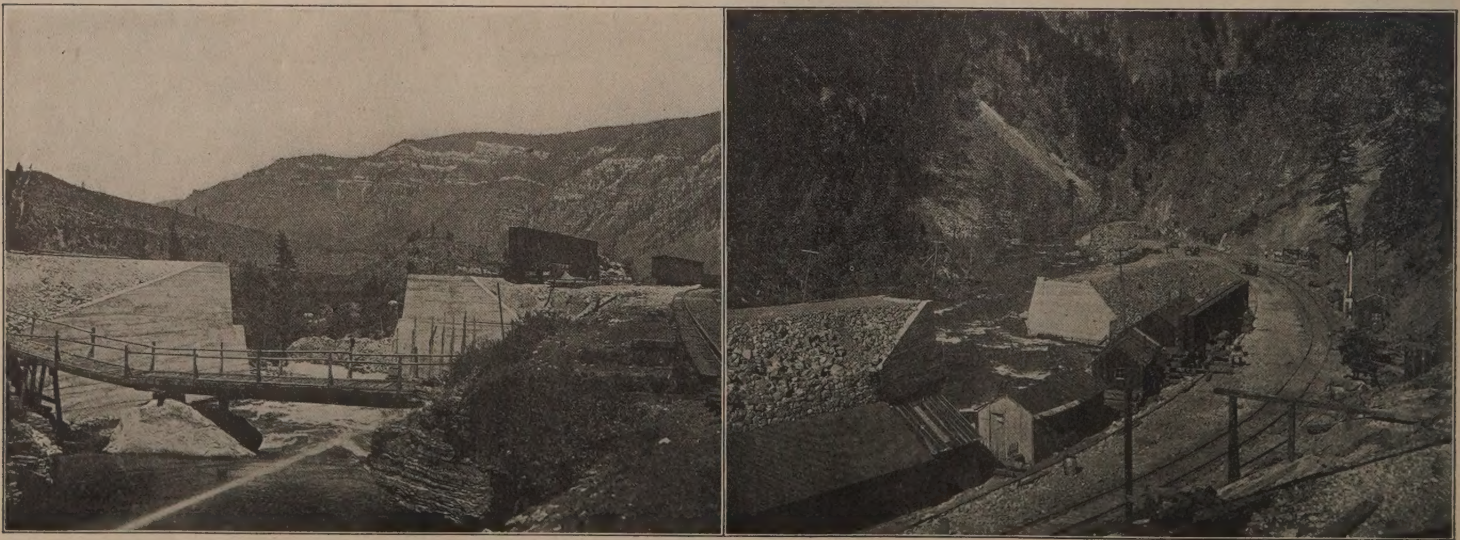
The entire work of construction was carried on without interruptions to traffic, and the new track was placed in operation for east-bound trains on Oct. 27 last.

The Union Pacific Gasoline Motor Cars.

For operation on its branch lines which do not furnish enough passenger business to be conomically or satisfactorily handled with trains drawn by locomotives, and in order to give a more frequent service on other lines, the business of which will not warrant additional steam trains, the Union Pacific R. R. Co. has developed in its Omaha shops a remarkably efficient gasoline motor car.

This type of car, namely, the straight gasoline transmission, was chosen for the reason that it could be most satisfactorily operated in connection with steam freight service, and would be economical for a volume of passenger business too small even for electrical operation. Before undertaking the designs for the motor cars, a careful study was made of the various types of cars already experimented with or in use. In Europe, more headway has been made with the self-propelled car in a general way than in this country, where more attention is paid to the steam car. This is readily accounted for by the fact that the development of the self-propelled car has been largely by railway men, thoroughly acquainted with the steam locomotive and having a very limited knowledge of gas engine power.

In the investigations, two methods were available, one in which the engine transmits its power directly to the axle, and the other in which the engine drives an electric generator that furnishes current to motors connected to the axles. The latter was considered to have a number of objections, namely, additional first cost for generators, dynamos, storage batteries and controlling mechanism, and a great additional weight, loss in efficiency, and complication of electrical



Abutments for Bridges 296A and 297A on the New Second Track.

and mechanical problems. While the electrical transmission has the advantage of being able to drive more than one axle, the objections to the system so far outweighed the advantages in the opinion of the company's engineers that straight gasoline transmission was decided upon.

A four-wheel experimental car 31 ft. long, weighing about 40,000 lb., and equipped with a 100-h.-p. engine, was completed in March, 1905, and immediately put through a series of most exacting trials.

Although not intended for pulling trains, its tractive power was tested by attaching two passenger cars weighing together 112,100 lb. With this load the motor ascended a one-third per cent. grade, and also stopped and started several times on the grade without difficulty. With one car weighing 52,100 lb., it ascended a 1.6 per cent. grade at a rate of 11 miles an hour. After successfully making a trip under its own power from Omaha to Portland, Ore., and return, including the steep ascent of 27 miles on Sherman Hill, the motor went into daily service on one of the company's branch lines, 65 miles long, making the round trip daily.

As soon as sufficient experimental data had been secured through operation of this first car, and the management felt seasonably sure of the ultimate success of cars designed along these general lines, designs for an improved motor of greater capacity were worked out and up to the present time fourteen of these cars have been completed and put into operation, while there are still seventeen more to be completed during 1907.

The cars are 55 ft. long, with a seating capacity of 75 passengers. They weigh approximately 58,000 lb. They are provided with two four-wheel trucks, with 33-in. wheels, except the front driving wheels, which are 42 in. in diameter.

The car body is unique in many ways. Its rear end is semi-circular, to reduce to a minimum the air suction when the car is running, at the same time making a beautiful observation end, which is appreciated very highly by the passengers. At its front end, the sides of the car gracefully curve to a point, and the roof is curved down to the eaves, giving somewhat the appearance of the bow of an inverted boat. The object of this peculiar contour was to reduce to a minimum the air resistance when running at high speed.

In the tests made on the electric line between Berlin and Zossen in Germany, and also by the Electric Railway Test Commission, during the Louisiana Purchase Exposition, the great advantage of the wedge-shaped front end was demonstrated. These tests showed that the parabolic front offered only one-fourth the resistance that a car with a square flat end did. From the results obtained in these tests, the parabolic front end on the car would offer a resistance equivalent to 21.9 h.-p., while a plain flat end would offer a resistance equivalent to 87.5 h.-p. under the same conditions.

To secure the maximum strength in the car body, with minimum weight, and in order to have practically a fireproof car, the body is built wholly of steel. The prevailing type of roof used in wooden cars, with upper deck and ventilating sash, has been entirely discarded, and is superseded by a semi-elliptical roof, which, without sacrificing the comfort of the passengers, has been made 2 ft. lower than the old standard design. With this new tpe of roof, a car of great stiffness can be secured, with comparatively light steel posts and carlines, by uniting these parts into one piece of 2-in. channel section, extending from the side sill on one side, continuing around and down the other side of the opposite sill.

The underframe is unusually light and well braced. A single center sill is formed of an 8-in. I-beam with side sills of 6-in. channels. The body bolsters are of cast steel.

The round windows are a distinctive feature of this car, made in somewhat the same manner as the port-holes in a ship, only very much larger, and give promise of being brought into very general use in passenger car equipment in a very few years for the reason that they give an absolutely water and dust-proof window. The side wall of the car is only 2 in. through, in place of 6 or 7 in. as in the average coach, giving a more continuous view of the country to the passengers, and allowing the use of a wider seat, which increases the capacity of the car some 25 or 30 per cent.

The car is ventilated by a forced system of ventilation, fresh air being taken in at the top of the car at the front end, and distributed along the floor, the foul air being exhausted through ventilators in the roof.

The car is heated mainly by hot water coming from the cooling system of the engine, water being circulated through coils of pipe on both sides of the car. In summer, the engine jacket water is circulated through pipes under the car, and during the successive changes in temperature, the amount of water passed into the car for heating purposes is very nicely regulated.

The car is lighted by electric light or acetylene gas, the individual lamp system being used, placing a lamp over each seat, giving a beautiful clear light for reading, the light being behind an oval opalescent globe.

The interior of the car is finished in Cuban mahogany, the ceiling painted in soft colors pleasing to the eye. Comfortable upholstered seats are provided, suitable for seating three in a seat.

The engine compartment, as in all cars, is at the front, taking up about 12 ft. of space. The balance of the car is devoted to seating space for passengers. Two of the cars turned out have been built with a small baggage compartment back of the engine room. The entrance for passengers is at the side of the car, near the center, which does away with the necessity of rear-end vestibules, facilitates the loading of passengers, and when the car is running, the doors are closed and steps are not exposed to the elements.

The engines have six cylinders, connected in opposed sets of three cylinders each, so that the crank shaft receives three power pulsations per revolution. Although in general appearance the engines resemble somewhat the form used in automobiles, they are built with special reference to railroad service and the severe duty imposed upon them. The engine is located on the forward truck of the car between the bolster and the front or driving axle, and supported on the side frames of the truck. Eight spiral springs over the truck wheels carry the engine, while the car body is carried on elliptic springs under the truck bolster, thereby preventing all vibration in the engine reaching the car. The power transmission from the engine to the axle is through a 5-in. silent-running chain.

Two speeds only are used, one for starting the car, and the other thrown into commission after running about a car length. No power is transmitted through gears in the high speed, which is used 95 per cent. of the time, everything being locked, making a direct drive from the engine to the axle through the chain.

The engine is a reversible engine and can be run just as readily backward as forward. The speed of the engine is regulated by throttling the supply of gasoline, and this method has given the greatest satisfaction. Care has been used in designing inlet piping from the carbureter, to give an equal supply of vapor to each cylinder.

Compressed air is supplied through a pump driven by an eccentric on the main shaft of the engine, the air being stored in suitable reservoirs and being used for starting the engine, braking the car, the whistle, and sanding the rails. The reverse, throttle and spark advance levers are all conveniently located near the operator's post, as are also all air connections for operating the gear clutches; in fact, everything required in the handling of the car is located at either hand of the motorman. A straight air brake system is used, braking with 60 lb. brake cylinder pressure, while the main reservoirs carry from 110 to 150 lb. of air.

On the first seven cars a 100-h.-p. engine was used, having cylinders 8 in. in diameter with a 10-in. stroke. The eighth car and all cars following it are equipped with 200-h.-p. engines having cylinders 10 in. in diameter with 12-in. stroke. On a long-distance trial on the main line of the Union Pacific, a car equipped with a 100-h.-p. engine followed Overland Limited out of Omaha, running as second section of that train, leaving the depot ten minutes behind the first section. After covering 46 miles the motor car was continually held by the block of the limited train. A run of 153.6 miles was accomplished in 4 hours and 32 minutes, or 34 miles per hour. A maximum speed of 53 miles per hour was obtained.

One of the recent cars, with a 200-h.-p. engine, on Aug. 3, followed the Overland Limited out of Omaha and was held by her block continually. At Lexington, 220 miles from Omaha, the motor car was allowed to run ahead of the Overland Limited, and from Lexington to North Platte, with a clear track, she made a maximum speeds of 65 miles per hour, and went into North Platte 40 minutes ahead of the limited.

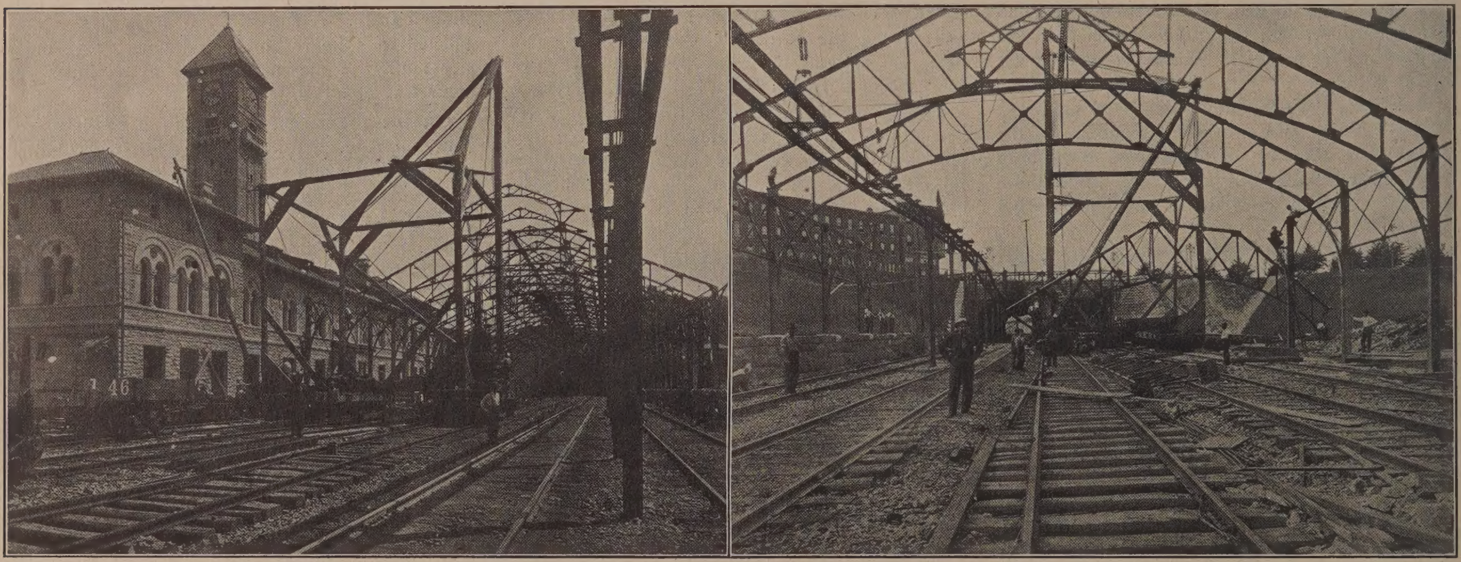
The cost of operation varies more or less with the length of the run the cars are making, and it is hard at this time to give any definite figures on operation, but the consumption of gasoline averages from 3 to 4 miles per gallon, according to the class of service and grades on line, making the cost of fuel in the neighborhood of $3.50 per 100 miles.

The original suggestion in regard to the development of a self-propelled motor car, was made by Mr. E. H. Harriman, president of the Union Pacific Railroad. Under the direction of Mr. J. Kruttschnitt, director of maintenance and operation, and Mr. A. L. Mohler, vice-president and general manager, this car was designed, built and developed to its present form at the Omaha shops under the personal supervision of Mr. W. R. McKeen, Jr., superintendent of motive power and machinery, and his corps of assistants.

A CHAIN AND BUCKET DREDGE designed to raise 600 tons of material per hour from a depth of 66 ft. below water level was completed last summer for the port work at Rio de Janeiro, Brazil, according to "Engineering," London. The work on which the dredge will be used comprises 6,000 linear meters of quay wall, having a minimum depth of water alongside of 33 ft. at mean tide, and a channel 800 ft. wide and 33 ft. deep from the natural deep water. The dredge, which is named the "Affonso Penna," is 176 ft. long, 35 ft. in breadth and 13½ ft. deep. On account of the depth to which it will work and the difficulty of the material encountered, stiff clay, the ladder carrying the buckets is built very heavy. It is 130 ft. long and weighs 200 tons. The section consists of two fish-bellied girders, with both the flanges and webs braced together at short intervals by diaphragm plates. The main spur wheels which drive the tumbler of the bucket-chain mechanism are made with removable rims, which slip in case a bucket strikes an immovable object. The buckets are made very heavy and have cutting edges of high-quality steel.

Erecting Roof Trusses with a Tower Derrick.

Several years ago the steel framework of the freight shed at the Mount Royal Station of the Baltimore & Ohio R.R., Baltimore, Md., was rapidly and economically erected by a traveler which consisted of a simple 4-post wooden tower on top of which was mounted a stiff-leg derrick with a length and capacity sufficient to command all parts of the shed and assemble the different members which were temporarily braced or guyed until their final connections were made. The traveler was mounted on two flat cars furnished by the railroad company and was operated by a hoisting engine seated on one of the cars which together with the pile of old castings provided the counterweights for the derrick reactions. The traveler mast was independent of the tower post and was free to swing nearly 270 deg., thus giving a wide sweep to the boom. The traveler was run back and forth parallel with the axis of the train shed and was moved, with full load swinging from the boom, by lines operated by the capstan heads of the hoisting engine.



Tower Derrick Unloading Material and Erecting Assembled Roof Truss.

The traveler tower 25 ft. square and 30 ft. high was built throughout with 10x10-in. and 8x8-in. vertical and horizontal timbers and single ⅞-in. square X-brace rods in all panels, both vertical and horizontal. The corners of the vertical panels were knee-braced by planks bolted across the outer faces of the timbers. The boom was a 10x10-in. timber 50 ft. long connected to the foot of the tower and had a capacity of 5,000 lb. live load and 1,000 lb. dead load at a radius of 35 ft. The mast had a total height of 50 ft. above the boom seat and its upper end was braced with two 8x8-in. stiff legs run to the opposite rear corners of the tower. The principal stresses developed by the 6,000-lb. boom load were 6,000 lb. in the boom, 4,500 lb. in the topping lift, 5,400 lb. in each back leg, 5,050 lb. in the mast, 10,000 lb. in the front tower legs and 6,550 lb. in one of the tower diagonals. Two 6,000-lb. counterweights were required at opposite diagonals in the base of the tower and the maximum reaction there was 8,400 lb.

The overhead electric cables for the belt line railroad were carried over the site of the train shed, suspended from steel towers erected over the track. These towers consisting of four vertical posts X-braced close together longitudinally and connected at their tops by a pair of very light transverse lattice girders with clearance for train service below their bottom flanges. The cables were first temporarily supported on vertical wooden posts shown in the accompanying illustrations and arranged to permit continuous traffic with the electric locomotives. The electric cable towers were then removed by the derrick boom in advance of the erection, great care being taken to prevent men or materials coming in contact with the live wires. Later when the wires were transferred to the shed and suspended from its new roof trusses the current was temporarily cut off.

The material for the main shed was shipped direct from the bridge shops and unloaded at the site by a special boom rigged for that purpose on the rear lower corner of the traveler. With the aid of the traveler booms when necessary the members of the trusses were assembled in a horizontal plane on blocking on the ground and the splices were field riveted complete before the trusses were erected as single pieces. The erection progressed rather slowly on account of the delays due to the maintaining train service and to the danger and difficulty from the electric current in the live wires; but in some cases as many as four complete panels of the structure were erected in one day.

The Maryland Penitentiary has riveted roof trusses of about 50 ft. span seated on solid masonry walls 60 ft. high without openings. The material for the trusses was delivered in sections outside the building and was lifted over the walls and assembled and riveted on the ground inside the building to make the complete trusses which were erected by a wooden traveler about 60 ft. high. It consisted of a rectangular tower two panels high with the stiff-leg boom derrick seated on top at one corner and operated by a hoisting engine carried in the base of the traveler. All jack rafters and purlins were erected by the same boom and a 16-ft. cantilever working platform was extended from the top of the traveler in front for use in placing the numerous light T-bars in the ceiling. Roofs were built on two long wings of the building which were so situated that it was necessary to take the traveler to pieces after completing one roof and re-erect it for the assembling of the second roof. This was accordingly done and the steel work was rapidly erected without accident. The work was fabricated and erected by the Maryland Steel Co., Mr. C. F. Spinney, engineer.

A Sixteen-Mile Cut-off is about completed on the Baltimore & Ohio R. R. between Lodi and Nova, O., reducing the distance by more than a mile and eliminating some heavy grades and curves. This cut-off will complete the double-tracking from Youngstown to Chicago Junction.

The Hydro-Electric Plant of the Black Hills Traction Co.

By Samuel H. Lea, M. Am. Soc. C. E., State Engineer of South Dakota.

In the Black Hills of South Dakota are several streams of considerable size, which have their origin among snow-capped peaks and are fed by springs along their upper reaches, thus maintaining a constant and fairly uniform flow. These streams, in the course of their descent to the plains below, flow in narrow valleys and have a heavy fall throughout most of their length. These features are especially valuable for hydraulic power development; several water-power plants have been constructed, and others are projected on the streams among and adjacent to the Black Hills.

The Redwater River is a stream which is fed largely by springs, and which, having swift and steady flow in its channel, is but little affected by floods or freshets. It has a rapid fall along its entire course and is practically free from ice even in the coldest weather. It is, therefore, valuable as a source of power, both on account of the high power-head afforded by its rapid fall, and also because there is no danger to wheels or machinery from floating ice, as would be the case in a colder stream. This river has been utilized for power purposes by the Black Hills Traction Co., whose hydro-electric plant near the town of Spearfish, S. D., has recently been completed. This plant is a good example of modern hydraulic power construction, and it is thought that a description of it would be of interest. Before going into detail, however, a brief statement will be made concerning the use of water for beneficial purposes in South Dakota.

Under laws of South Dakota, the State has control of all the waters in the State, except navigable streams; and all applications of water to beneficial use in this State must be made under the supervision of the State Engineer. In each case of the appropriation of water a permit therefor must be obtained from the State Engineer's office. In the case of the construction of a dam and diversion works detailed plans of same must accompany the application for a permit and must be approved by the State Engineer. The writer, as State Engineer, is necessarily in close touch with all matters connected with the appropriation and diversion of water from the various streams in South Dakota, and is more or less familiar with the details of plans for hydraulic power development in the State.

Wood-Stave Pipe Line.

Typical View of Canal.

The point of diversion of the water is about 2¼ miles east of the South Dakota-Wyoming boundary; it is about 10 miles southwest of the town of Belle Fourche, in Butte County, South Dakota. The water is taken from Redwater River just below its junction with Crow Creek. The volume of water taken is about 150 cu. ft. per second; this is conveyed about 5½ miles through canal and flume to a forebay situated 4,480 ft. distant from the power house and 117 ft. in elevation above same. From the forebay the water is conveyed to the power house through a wood stave, steel banded pipe.

The power house is situated on the bank of the river, well above the ordinary high-water level of the stream at that point. The transmission line is carried across country through the town of Spearfish to Deadwood, and thence to various mines in the vicinity requiring power. The accompanying views are from photographs taken at various places along the completed work.

The dam for diverting the water into the power canal is a rock-filled log crib structure, 12 ft. wide on the top, and having an apron faced with 3 in. plank, extending 25 ft. downstream. The crest of the dam is 100 ft. long between the end cribs, giving a spillway of ample size. Anchorage to the underlying formation of clay was obtained by means of piles, driven to a depth of from 4 to 6 ft., and a row of sheet piling was driven along the upper face of the dam for a cut-off. On the upstream face of the sheet piling was placed a backing of earth, well puddled and with a broad base. The crest line of the spillway is 8 ft. above the bed of the river, and the total width of base is 60 ft. This construction has afforded satisfactory results and the dam is in excellent condition both as to water-tightness and solidity after over two years of use.

The intake has an entrance width of 16 ft., which narrows to 12 ft. at its connection with the canal. The flow of water is regulated by three valves, each 4x6 ft., placed at the head of the intake. No special precaution was considered necessary for preventing the passage of sand or silt, as the water is unusually free from floating detritus.

The canal is 12 ft. wide on the bottom with side slopes varying according to the nature of the material. It is designed to carry 4 ft. depth of water at a mean velocity of 2 ft. per second.

For the greater part of its length the canal was excavated in earth with side slopes of 1 to 1. Where rock was encountered the side slopes were made as steep as ½ to 1. In several places along the route where the ground was low, an embankment was made on the lower side of the canal line and the water was allowed to spread out and form a pond on the upper side. In this way considerable storage was obtained where most needed for taking care of peak loads.

At several points along the route streams and valleys are crossed and at these places the water is carried through a timber flume of rectangular cross-section. This flume rests on mud-sills spaced 6 ft. apart on banks; where openings are crossed, it is supported on pile bents, spaced 12 ft. apart, each bent containing three 12-in. piles. An interesting feature in its construction is the method used in connecting the flume with the canal at junction points. This is effected by means of a concrete apron which acts as a lining for the canal at the point of connection, and to which the flume is fastened by means of ¾x16-in. bolts at the sides and ¾x24-in. bolts at the bottom.

The forebay consists of a natural basin or reservoir into which the canal discharges. The lower end consists of an earth dam into which is built the upper end of the water conduit. Where surrounded by the dam structure the wood stave pipe is protected by a ring or covering of concrete. The entrance to the pipe line is protected by an inlet wall, with screen for preventing the entrance of foreign matter into the conduit.

From the forebay to the power house, a distance of 4,480 ft., the water is conveyed through a wood stave, steel-banded pipe 6 ft. in diameter. Just above the power house this 72-in. pipe is divided by a Y-branch into two 54-in. pipes which convey the water to two separate units. Each unit consists of a Pelton Francis turbine waterwheel, capable of developing 1,068 h.-p., which

Interior and Exterior Views of the Redwater Power Plant.

is direct connected to a 500-kw. Westinghouse generator, which runs at 400 r. p. m.

The wood-stave pipe is built of Washington fir. The staves of the 72-in. pipe are 2½x8 in.; those of the 54-in. pipe are 2x6 in. The pipes are banded with ⅝-in. steel rods, spaced according to pressure, with a factor of safety of four. A 38-in. riser is built just above the junction of the 72-in. pipe with the two 54-in. pipes, to relieve the pipe line of water ram.

The power house is a substantial masonry structure with the interior arrangement of machinery shown in the accompanying illustration. There are two main units, each with a capacity of 1,068 h.-p., as stated above, and two direct-current exciters, each having 35-kw. capacity at 125 volts. These are operated at 1,050 r. p. m., and are direct-connected by face couplings to 50 h.-p. water wheels of the same make as the large wheels. A 10-ton traveling crane is mounted on overhead runways. The governor is of a type made by the Pelton Water Wheel Co., of San Francisco, Cal. It is especially adapted to the Francis type of turbine, operating under high head, such as is used in this installation.

The transformer house contains seven 180-kw. Westinghouse water-cooled transformers, which raise the initial voltage of 440 to 24,000. The current is transmitted over a pole line a distance of 23 miles to Deadwood and vicinity for use in the mines and mills.

At a test run made at the plant in April, 1907, 1,683 h.-p. were developed on a switch board. The calculations are that the company will be able to deliver 1,200 h.-p. continuously at the end of its transmission lines.

An important factor in the efficiency of the installation, one which insures continuous service summer and winter, is the fact that about one-half of the water supply comes from Crow Creek, a stream which originates in springs less than one mile above the head works and whose water enters the canal at a minimum temperature of 46°, thus preventing the formation of ice in the canal during the coldest weather.

The company is a South Dakota corporation, owned almost exclusively by residents of the town of Spearfish. Mr. H. S. Vincent, C. E., of Deadwood, S. D., was the engineer of the company during construction, and Capt. R. M. Jones, of Denver, Colo., planned and installed the power station and equipment. Henry Keets, of Spearfish, is the president and manager of the company. To him is due the credit of promoting, organizing and financing the proposition and of carrying it to a successful completion.

When the fact is considered that all of the construction material and the heavy machinery used in this plant was hauled several miles over mountain roads from the nearest railway station, it is evident that the building of this plant in its isolated location, was an undertaking of some magnitude.

A Suspended Track Scale with a capacity of 200 tons has been installed for the Jones & Laughlin Steel Co. by the Standard Scale & Supply Co., Pittsburg. The levers are carried above the track by a steel structure, consisting of four gallows frames supported on concrete piers, which rise 5 ft. above the ground. The columns on each side of the track are braced by horizontal members and by X-bracing. Heavy knee-braces are provided between the columns, and the horizontal beams spanning the track to give transverse rigidity. The platform is 46 ft. long and its weight is carried to the scale levers on top of the steel frame by eight vertical rods. The advantage of the construction lies in the removal of the scale levers from the ground pit, where they are frequently affected by moisture and bad drainage.

Moving a Large Statue.

In the construction of the Philadelphia Rapid Transit Subway around City Hall Square it was necessary to excavate under the site of the equestrian statue of General McClellan, a tall and heavy structure, with a cut-stone base, on which was seated a heroic-size bronze statue, reaching to a height of about 25 ft. above the street and weighing about 75 tons. It was supported on an 8 x 14-ft. rubble masonry foundation, reaching about 7 ft. below the surface.

An excavation was made around the foundation to the bottom of its footing, and from it narrow tunnels were cut through the rubble masonry to receive twelve 12-in. I-beams, 20 ft. long, the outer ends of which were bolted together with separators, while the monument was still supported on the uncut rubble between the I-beams. The lower part of the monument was partly encased in wooden sheathing to protect the arrises of the stone work; wedges and packing were fitted to the upper flanges of the I-beams to provide bearing against the base of the monument, and jack screws were placed under their outer ends, reacting against timbers laid in the bottom of the trench.

Moving McClellan Monument on Rollers.

The monument was lifted about 6 ft., care being taken to follow up the jacks with solid crib work piers. Ten or twelve lines of 2x10-in. planks were laid flat on the pavement, with 10-in. spaces between them, making a wide, thin grillage or distributing platform, across which were placed 12 x 12-in. timbers, 20 to 24 ft. long and 3 ft. apart on centers. At distances of about 7 ft. and 10 ft. from the street side of the center line longitudinal stringers, four in all, were laid on top of the timbers, each line consisting of two 2 x 12-in. planks in long lengths, one on top of the other breaking joints. On each pair of stringers 4 x 6-in. transverse pieces 4 ft. long were set about 18 in. apart, and occasional pieces were bolted to the stringers. On each of the two beds thus formed two ordinary 60-lb. T-rails, 30 ft. long, were laid about 2 ft. apart, and were spiked to occasional cross-pieces. The ends of these tracks projected over the excavation on each side of the monument and were supported there on cribbing.

About 20 solid steel rollers 3 in. in diameter and 30 in. long were arranged on each track placed a 12 x 12-in. longitudinal timber, 20 ft. long, with a 12 x ½-in. track plate on the lower surface to receive the roller bearings. The jack screws were simultaneous slacked off and lowered the monument about 3 in., until the projecting extremities of the needle beams took bearing on the longitudinal stringers, and the jacks were released and removed. A few of the jack screws were then set near the horizontal plane against the rear needle beam and the base of the monument, reacting against sills and inclined timbers seated on the ground, and the monument was gradually pushed forward on the tracks, the live rollers being constantly disengaged and removed from the rear and put under the front.

When the monument reached the front end of the track the second section of plank grillage was laid on the surface of the street, the ends fitted in each section, timbers were laid upon it, as already described, and a second section of track rails joined to the first. After the monument had advanced upon it the first section of track and grillage was removed and relaid in front, and so on until the monument had been shifted about 75 ft. to a place near the City Hall, where it did not obstruct traffic and could remain undisturbed until the completion of the subway.

At the site of the monument special bents of heavy columns and roof girders are introduced in the subway construction, and on them foundations will be built to receive the monument when it is convenient to return it by the method already described to its original position. The raising and moving of the monument was accomplished in about two weeks by a force of ten men, employed by Henry Sheeler & Sons, Chicago, sub-contractors under the E. E. Smith Contracting Co., the general contractors who executed the work on the City Hall section of the subway, under the direction of the engineering department of the Rapid Transit Ry. Co., of Philadelphia, Mr. W. S. Twining, chief engineer, Mr. Chas. M. Mills, principal assistant engineer, and Mr. Frank R. Fisher, resident engineer.

Storage Battery Cars for railway service, weighing 42 tons loaded, are reported in operation on the Prussian state railways for three short runs, the longest of which is 12½ miles.

Comparative Performance of Steam and Electric Locomotives.

At the meeting of the American Institute of Electrical Engineers on Nov. 8 an unusually valuable paper on the performance of steam and electric locomotives was presented by Mr. Albert H. Armstrong, of the General Electric Co. As a clear explanation of some of the fundamental reasons underlying the electrification of steam roads, it deserves careful study. In general, the possible saving in fuel through the adoption of electric traction does not in itself amount to enough to pay an adequate return on the investment to obtain it, and it is necessary to look for more important benefits. These are to be found, in the author's opinion, in a comparison of the characteristics of steam and electric locomotives. Such a comparison is made in the paper, which claims a superiority for the electric locomotive in general railway work, and suggests the possibility of making, with its adoption, radical changes in the methods of operation now necessary with steam locomotives.

Owing to clearances, it is seldom that a locomotive can work at more than 90 per cent. of the theoretical full stroke, and hence the maximum tractive effort at starting with lever in the corner will not be much greater than 88 per cent. of the theoretical tractive effort available with gauge pressure in the cylinders. The steam locomotive is limited as to maximum tractive effort by its engine design, and limited as to the speed at which this tractive effort is available by the capacity of the boiler to supply steam. Thus, assuming that the locomotive will give 88 per cent. of its theoretical tractive effort when starting, it is capable of providing but 80 per cent. tractive effort at a speed of 10.6 miles per hour (with the constants of the particular locomotive chosen for illustration), at which the boiler is giving its full output. Hence higher speeds can only be reached with a less cut off and a consequent reduction in mean effective pressure and tractive effort. Locomotive engines are generally designed to give their maximum tractive effort at 90 per cent. theoretical cut-off at a point corresponding to a coefficient of adhesion of approximately 22 per cent. of the weight upon the drivers; that is, at about slipping point of steam locomotives with good rail conditions. It is immediately evident, therefore, that the tonnage rating of the locomotive on ruling grade must be so proportioned that the maximum tractive effort called for will be less than the available tractive effort of the locomotive, in order to provide a small percentage, say, 10 or 15 per cent., for possible starting under maximum grade and load conditions.

On the other hand, the tractive effort of the electric locomotive is limited only by the adhesion between driving wheels and rail, and, aside from some 15 per cent. greater adhesion possible with the uniform tractive effort provided by the electric locomotive, it is possible with this type of motive power to take momentary advantage of abnormally good rail conditions or to derive full benefit from the use of sand; indeed, tests have been taken with electric locomotives showing as high as 35 per cent. coefficient of adhesion between driving wheels and rail. This point is emphasized, as with the greater tractive effort of the electric locomotive it becomes possible to give them a higher tonnage rating for the same weight upon the drivers than would be possible with steam locomotives operating over the same track profile.

The accompanying diagram was prepared by Mr. Armstrong to show a concrete case of a 22 x 30-in. steam locomotive of the simple type, equipped with 57-in. drivers, contrasted with both an alternating-current geared and a direct-current gearless electric locomotive, designed for the same tractive effort, both maximum and running, but for a higher speed. The contrast of these different speed characteristics brings out sharply the small speed variation with different tractive efforts delivered by the electric locomotives, this small variation being even more marked in the case of the direct-current gearless than in the case of the alternating-current geared motor, working at a lower iron saturation and giving a more sloping speed characteristic.

The steam locomotive chosen is typical of those in general use upon mountain-grade divisions, the tonnage rating in operation of this particular locomotive being such as to call for a tractive effort of 25,600 lb. on average grade and 33,200 lb. on the maximum ruling grade, occurring on a certain engine division, thus leaving a margin of 6,300 lb. above the demands of maximum tonnage on maximum ruling grade for starting the train from rest.

The maximum speed available at the different tractive efforts is a matter of boiler capacity, condition of boiler, quality of coal and efficiency of fireman. The first of these factors, the boiler capacity, can be controlled by properly proportioning the design of the boiler to engine capacity, but there are three other factors which the locomotive manufacturer cannot control, and two of these factors constitute sufficient cause, Mr. Armstrong says, to warrant a considerable reduction in the theoretical rated capacity of the boiler. Thus, a locomotive in prime condition, carefully fired with coal of approximately 14,000 B.t.u., should be able to deliver full tractive effort at 10.6 miles per hour, but in practice it has been found that the average condition of boilers and the average firing curts the sustained boiler output down to not much more than 75 per cent. of its output under what must be considered exceptionally or momentary conditions. By sustained "output" is meant the output required while ascending the continuous up-grades on Western mountain divisions.

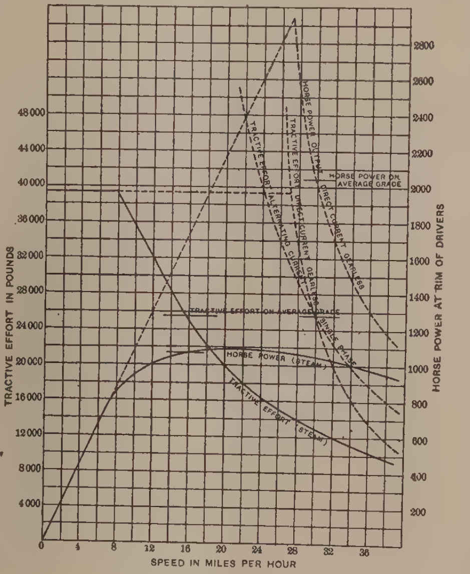


Diagram of Steam and Electric Locomotive Characteristics.

The locomotive characteristic in the diagram has been prepared on the basis of 75 per cent. of the possible boiler capacity, the general dimensions of the simple consolidation locomotive being as follows: Diameter of cylinders, 22 in.; length of stroke, 30 in.; diameter of drivers, 57 in.; heating surface, 3,397 sq. ft.; total weight of locomotive, 103.5 tons; weight on drivers, 93 tons; weight of tender, 61.5 tons; total weight locomotive and tender, 165 tons. This particular locomotive has been chosen for illustration, as it is the type in daily use on the mountain division of one of the largest Western roads.

Under the above conditions the theoretical tractive effort is 49,500 lb., of which 39,600 lb. is available at 90 per cent. cut-off. The contents of each cylinder is approximately 6.6 cu. ft., and, with four cylinders of steam per revolution and with steam weighing 0.41 lb. per cubic foot at 170 lb. cylinder pressure, each revolution requires 10.85 lb. steam. With 3,397 sq. ft. of heating surface there is a possibility of evaporating 6 lb. of water per pound of coal when burning 2 lb. of coal per square foot of heating surface, thus giving an available supply of 40,700 lb. of steam per hour when working boilers in prime condition at the full output, resulting from perfect firing, with good quality of coal. In practice, however, the available steam for sustained output would not be greater than 75 per cent., or 30,500 lb. per hour, thus giving full tractive effort at 46.8 revolutions of the drivers, corresponding to 7.93 miles per hour on a 57-in. driver. The "critical speed" of the locomotive is therefore 7.93 miles per hour when working at 75 per cent. of full attainable boiler capacity, and the coal consumed under such circumstances will be 4,360 lb. per hour, corresponding to 1.28 lb. of coal burned per square foot of heating surface, at which rate we would expect an evaporation of approximately 7 lb. of water per pound of coal consumed.

What might be termed the "performance capacity" of a steam locomotive may be worked out from the speed and tractive effort characteristics given in the diagram, using as a basis the 1,000 ton-miles trailing load moved per hour on a level or any gradient selected. The prevalence of 2.2 per cent. ruling grade on many Western roads perhaps justifies the selection of that figure for demonstration purposes; and the coal consumed, crew wages and maintenance charges may all be worked out from the basis of continuous operation per 1,000 ton-miles trailing load on 2.2 per cent. grade. The performance capacity obtained in this way is shown in an accompanying diagram.

Certain assumptions are necessary and are as follows: Cost of coal, $3 per 2,000 lb.; engineer, 50 cents per hour; fireman, 35 cents per hour; conductor, 40 cents per hour; three brakemen, 90 cents per hour; average mileage per locomotive per year, 36,500; total maintenance, including roundhouse charges, $5,000; maintenance per locomotive mile actually run, 13.7 cents.

The small speed variation of the electric locomotive and the fact that its motive power is separate from its unlimited source of power generation make it possible to consider radical changes in the method of moving freight, more especially on mountain-grade divisions. Steam railroading to-day is in reality steam locomotive practice, in that the speed possibilities of different track divisons are restricted to a large extent by the limitations of the steam locomotive. The only reason why it is common practice to run at very low speeds on mountain-grade divisions instead of continuing the high speeds in vogue on more level portions is because a steam locomotive cannot be built powerful enough to supply the heavy tractive effort required at any higher speeds than those now in vogue.

The one expense in train operation that is fundamental is the cost of fuel, this fatcor being influenced only by the economy of the fuel-burning plant. Other expenses, such as locomotive maintenance and crew wages, are affected entirely by the method of operation, and no radical departure from present methods is to be looked for until the coming of a type of motive power which offers possibilities not equally enjoyed by the steam locomotive. In general, it may be stated that the freight movement over mountain divisions is effected at very low schedule speeds, and the cause is evident from an inspection of the steam locomotive characteristic.

Except for the fact that curves are usually of shorter radius on heavy grades than on levels, there is no reason for the slower speed of trains, provided a type of motive power is available that is capable of supplying great draw-bar pulls at high speeds. It is just this characteristic which the electric locomotive possesses to an almost unlimited extent, and such locomotives can be built which are even more powerful and operate at higher speed than can be utilized at present.

The electric locomotive may be equipped with motors of several different types, each having characteristics best qualifying it for certain classes of work. The type to be adopted is a matter requiring full local knowledge of the conditions obtaining in each individual instance before a proper selection can be made. All three of the available motors, direct current, alternating current single-phase and alternating current three-phase, possess the one needed characteristic of great output per pound, and hence the arguments advanced for the substitution of the electric for the steam locomotive are general in character and do not apply strictly to locomotives equipped with any one type of motor to the exclusion of all others.

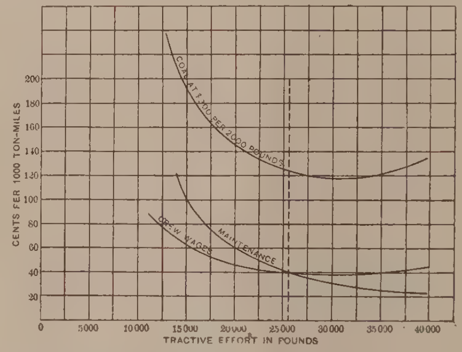
Returning to the direct comparison of the simple consolidation and electric locomotives, the diagram showing this comparison was plotted on the basis of a speed of 30 miles per hour for the electric and 15.4 miles per hour for the steam locomotive, giving in each instance a tractive effort of 25,600 lb. at the rim of the drivers. Though the electric locomotive could very readily be designed to give the same tractive effort at a higher speed, 30 miles per hour was assumed as the highest speed permissible, due to the alignment of the track on heavy grades. To plot a performance capacity curve for the electric locomotive certain further assumptions are necessary, as follows: Type of equipment, direct-current gearless motors; weight of total locomotive, 125 tons; weight on drivers, 100 tons; engineer, wages, 50 cents per hour; conductor, wages, 40 cents per hour; three brakemen, wages, 90 cents per hour; efficiency of transmission, rail to bus-bar, 70 per cent.; maintenance of locomotive, 5 cents per mile run. The train crew is so divided as to permit the location of a brakeman in the engineer's operating cab.

The cost of electrical power must in this instance be most arbitrarily assumed, owing to the widely different cost of coal, possibility of water-power, etc., obtaining in different localities. As the cost of coal for steam locomotives will also vary greatly as to price and quality, it has been assumed at $3 per 2,000 lb., and a cost for electric power of ½ cent per kilowatt-hour is based upon using the same price and quality of coal. As it is further assumed that an entire engine division of, say, 150 miles is to be electrified, it gives promise of a 24-hour load-factor of 50 per cent., and this figure has been taken. Approximating the first cost of installation of the generating station at $100 per kilowatt, and allowing 10 per cent. per year for interest and other fixed charges, the cost of power is brought up to possibly $0.0075 per kilowatt-hour at the station bus-bar. Other conditions obtaining will in a given instance modify the figures arrived at, but for purposes of demonstration $0.0075 is a conservative estimate, and such a figure is needed to compare the cost of power with the fuel item in steam-locomotive performance.

The effect of increased speed on cost of operation is clearly shown by comparing the performance capacity curves of the steam and electric locomotives.

It will be observed that the reduction in the operating expenses is effected in the two items of crew wages and maintenance of locomotives, and that the cost of fuel remains practically unchanged. This is as it should be, as the cost of fuel in the case of steam locomotives or power with electric locomotives is the only fundamentally necessary expense in train movement. Overcoming train friction and raising a train up grade against gravity represents useful work performed, and this work is accomplished at an expenditure of approximately 4 lb. of coal per horsepower-hour at the drivers with simple engines and 2.66 lb. of coal per horsepower-hour at the drivers with electric locomotives, including all intervening losses between rail and generating station bus-bar. The speed at which this work is performed, therefore, does not affect the cost of fuel or power, it being assumed that the motive power for the various speeds is so proportioned as to operate at the point of greatest economy.

While the diagrams of performance capacity indicate a certain relation among the three items of fuel, crew and maintenance expense, this is not the true relation obtaining in practical operation, for the reason that the values given in the curves assume continuous operation up-grade under the conditions outlined. Unfortunately, train crews must be paid full value per mile, whether the mile be up grade or down, and with steam locomotives there is also a considerable loss in fuel resulting from engines standing or running light, which must be also taken into account; hence, it becomes necessary to modify the figures arrived at, and for this purpose certain references must be made to current railroad practice on mountain-grade divisions, in order to arrive at the proper tonnage relations, schedule speeds, etc., obtaining in up-grade and down-grade operation.

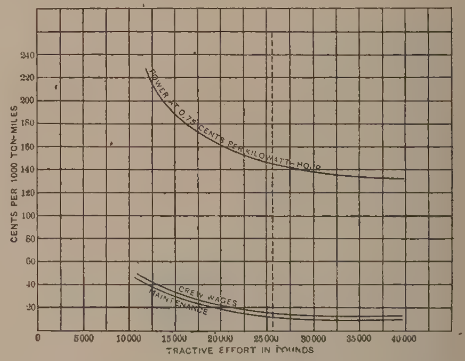


Performance Capacity of Simple Steam Locomotive on 2.2 per cent. Up-Grade.

The schedule speed on several mountain divisions is approximately 50 per cent. of the average running speed, and this figure is assumed in the following statement of cost of operating 1,000 ton-miles with steam locomotives, averaging the cost of up and down grade running. Owing to the higher schedule speed of electrically operated trains, resulting in fewer meeting points with the same tonnage handled, and owing to the absence of forced stops to take on fuel and water, etc., it is assumed that with electric motive power the schedule speed may be 60 per cent. of the running speed.

With the electric locomotive standing, or coasting down grade, there is no demand whatever made upon the generating station, and hence the only expense carried through these periods is that for train crew and a certain amount for maintenance. On the other hand, with the steam locomotive there is a considerable amount of fuel burned and water wasted when standing at sidings and when coasting. In the case of mountain railroading, with its frequent and prolonged delays, this waste may reach considerable proportions.

The following results of a carefully conducted series of tests will illustrate this point. Two test locomotives and trains were operated over a mountain division under regular service conditions, steam and fuel consumption, duration of delays, etc., being carefully noted. The total work expended up grade was 5,700 h.-p.-hr. at the rim of the drivers, including allowance for 1.54 per cent. average grade and 7 lb. per ton track and curve friction. The total water evaporated on the trip, divided by the total horse-power hours, gave a steam consumption of 36 lb. per brake horse-power-hour at the rim of the drivers. Indicator cards taken upon the engine in question at all cut-offs up to 90 per cent. showed that the greatest steam consumption did not exceed 32 lb. per indicated horse-power-hour, or 35.5 lb. per brake horse-power-hour, allowing 10 per cent. internal engine friction. Values as low as 23 lb. of steam per indicated horse-power-hour, or 25.5 lb. per brake horse-power-hour, were recorded for the average cut-off of 40 to 50 per cent. used throughout the run. A third and fourth series of tests conducted up the same grade gave similar results, except that the values were slightly higher than those quoted, showing that there was a considerable loss of water unaccounted for by indicator cards and useful work performed.



Performance Capacity of Direct-Current Gearless Locomotive on 2.2 per cent. Up-Grade.

Operating down grade, it was necessary to accomplish 1,110 h.-p.-hr., on account of the somewhat broken profile, and again the water consumption showed on two trips 57.7 lb. of steam per brake horse-power-hour, and on two subsequent trips 66.5 lb., values entirely unaccountable on the basis of useful work performed.

During all tests the usual service delays occurred, and, as the traffic on the road in question was very much congested, these delays constituted a considerable proportion of the total elapsed time. In fact, during the runs up grade the trains were in motion but 66 per cent. of the total elapsed time, and down grade the trains were in motion from 52 per cent. down to 40 per cent. of the total elapsed time. As these delays were frequent and undetermined, it was necessary to maintain full steam pressure while waiting for the momentarily expected release from the block, hence the waste of fuel and water was considerable. Averaging this waste at 400 lb. per hour, at which low rate of consumption the water evaporation would approximate 10 lb. of water per pound of coal burned, or 4,000 lb. of water evaporated per hour, and reducing the total water consumption measured by the waste losses thus obtained, the steam consumption in eight different tests up and down grade ranged 34.7, 32.4, 28.1 and 25.3 lbs., etc., water per brake horse-power-hour. These values are fairly commensurate with results of indicator cards taken, and, with the type of engine used and under the operating conditions obtaining, an allowance of 400 lb. of coal stand-by losses per idle locomotive-hour seemed not too great a value to allow, and this figure has been taken in subsequent calculations.

Locomotive performance capacity curves may therefore be plotted which will show approximately the true relation between the several items of fuel, crew wages and motive power maintenance, under the given conditions. Such curves are given in the paper and show that in practical operation the fuel expense approaches more nearly to the value of the other items considered, instead of being greatly in excess of them, as indicated in the theoretical performance curves, showing up-grade operation only. For operation on lesser grades than 2.2 per cent. all items are reduced, and the total and subdivided comparative costs are given in the accompanying diagram and table:

Comparative Operating Expenses per 1,000 Ton-Miles of Simple Steam and Electric Locomotives; Average of Up- and Down-Grade Operation.

Steam Locomotives.

Grade	½%	1%	1½%	2%
Coal	15 cts.	25.5 cts.	38 cts.	53 cts.
Crew	13.5 cts.	24 cts.	36 cts.	50 cts.
Maintenance	10.5 cts.	17.8 cts.	26 cts.	36 cts.
Total	39 cts.	67.3 cts.	100 cts.	139 cts.

Electric Locomotives.

Grade	½%	1%	1½%	2%
Power	20 cts.	35.5 cts.	50.5 cts.	66 cts.
Crew	7.2 cts.	12.2 cts.	18 cts.	24 cts.
Maintenance	3.6 cts.	6.2 cts.	9.0 cts.	11.9 cts.
Total	30.8 cts.	53.9 cts.	77.5 cts.	101.9 cts.

Saving effected by electric operation.

Grade	½%	1%	1½%	2%
	8.2 cts.	13.4 cts.	22.5 cts.	37.1 cts.

A study of the table shows that, while the percentage saving with electric operation is approximately the same whatever the ruling grade, yet the actual money saving is much greater on the heaviest grades. As about the same investment must be made in each case for distribution system, including third-rail or overhead trolley, sub-stations, etc., the inference must be drawn that heavy-grade divisions present a more attractive field for electrification than level sections, when considered from the purely economic standpoint. There are other items of saving and other reasons for electrification which may be more or less controlling in individual cases, but it seems possible to make the broad statement that the mountain-grade division offers a particularly attractive field for the electric locomotive, and its introduction should be the means of affecting such economies in both freight and passenger transportation as to pay a satisfactory return upon the investment required.

So far, the matter has been viewed from the standpoint of comparative operating expenses for a given tonnage moved. There is another argument for electrification which may in certain instances be of a much more controlling nature. Most of our mountain roads are single track, and transcontinental tonnage has so increased as seriously to congest these mountain divisions. The heavy trains of the plains, weighing 2,000 to 3,000 tons, must be split up into units of about 1,000 tons, in order that the present steam engines, operating double and even triple, may haul them over the heaviest grades. The slow speed obtainable makes the number of trains on a mountain division large, the meeting points frequent, hence however good the despatching system employed, there will of necessity be a considerable amount of lost time introduced. Add to this the failures of motive power being worked to its limit, and there is reason for the claim that the tonnage capacity of the mountain division will be greatly increased by the introduction of electrically hauled trains.

Lest the writer be accused of unfairness in selecting the simple engine for comparison, it is proper to touch upon the economies effected with the use of the compound locomotive and also by the introduction of such coal-saving devices as superheaters and feed-water heaters.

There is a saving of approximately 20 per cent. in water consumption per horse-power with the compound locomotive, but in spite of this generally accepted saving the simple locomotive still rules the mountain division, after repeated trials of the compound. Not being an ardent supporter of either type of locomotive, Mr. Armstrong leaves the battle of the simple and compound to their enthusiasts, commenting only upon the fact that, except in the case of the Mallet compound, the arguments for the compound are based upon fuel economy only.

The latest Mallet compound, weighing 413,000 lb., is the largest steam locomotive yet built and is of particular interest, owing to the enormous boiler which such a construction permits. With a total heating surface of 5,300 sq. ft., we should expect an evaporation of 63,600 lb. of water for a short period and possibly 48,000 lb. of water continuously. With a possible evaporation of 6 lb. of water per pound of coal, this would necessitate the burning of 8,000 lb. of coal per hour, requiring the best efforts of two firemen if maintained for several hours. Assuming a steam consumption of 22 lb. per brake horse-power-hour, such a locomotive should give a sustained output of 2,180 h.-p. at the rim of the drivers, and this with a weight, with tender, of approximately 300 tons, or three times the weight of an electric locomotive of the New York Central 6,000 type, giving the same horse-power output.

The two locomotives are, of course, designed for entirely dissimilar classes of work; but it is not unfair to compare them on a horse-power basis, as it is the huge boiler of the Mallet that is remarkable, and upon this basis the selling price of the machines is approximately the same.

The comparative cost of electric and steam locomotives is generally considered as very favorable to the steam units, but reversing the usual methods and comparing the cost of the electric with that of the steam locomotive or locomotives required to replace it may reverse the relations. The electric locomotive requires no more than casual inspection, can be sidetracked indefinitely and still be ready for instant operation at full capacity, can run 24 hours without a stop, if necessary, and all these advantages and others offer a guarantee for a much greater annual mileage than is possible with its steam competitor. Then, too, compare the cost of a group of steam locomotives (no single unit could be designed to give the output) capable of delivering even 4,000 h.-p. continuously with a single electric unit of this output, and the difference in cost is not great. It may be stated broadly that for a given gross annual ton-mileage moved, the cost of steam locomotives may be even greater than the cost of the electric units replacing them.

The term "horse-power" is perhaps not fully appreciated. When the statement is made that a certain electric locomotive is rated at so many horse-power output, it does not leave the impression it should. The horse-power output of a locomotive is a direct measure of its capacity to do work, and while the tractive effort available governs the tonnage of the trailing load, it is the product of the tractive effort times the speed at which it is available, or, in other words, the horse-power output, that measures the hourly tonnage capacity of the locomotive upon which the crew expenses of the entire train depends. Hence the great claim for recognition of the electric locomotive lies in its great horse-power output, that is, its ability to carry full tractive effort or to slip its wheels at speeds two or three times greater than can be done with any steam locomotive yet built.

Superheating promises something in fuel economy, as does the introduction of feed-water heaters. Such improvements, together with the adoption of the four-cylinder locomotive, either compound or simple, must necessarily call for more expense to maintain and less reliability in operation.

As against the reduction in fuel expenses promised by the use of the compound locomotive fitted with superheaters and feed-water heaters, the electrical engineer has the great possibilities offered by regeneration of power while electrically braking on mountain-grade divisions. The amount of power saved by this means may in certain installations amount to as great a percentage of the total as is the saving effected in coal expenditure with steam locomotives by compounding and providing superheaters and feed-water heaters. Such an electrical saving is, of course, restricted to heavy-grade divisions, but the feasibility of electric braking by regeneration is unquestioned. Indeed, with three-phase induction motors regeneration is automatic, the motors being perfectly reversible and returning energy when operating down grade, with no change whatever in their connections. Other types of motors may be adapted for regeneration, with slight modifications in the control system.

All of our railway managements have felt the need of establishing a so-called express freight service, comprising a light train operating at much higher speed than is the case with the bulk of the freight movement. It is well known that the cost per 1,000 ton-miles for moving express freight is very much higher than in the case of low-speed freight. An inspection of the diagram of steam and electric locomotive characteristics illustrates the reason for this. The steam locomotive is essentially a slow-speed unit when delivering its full tractive effort; that is, a tractive effort equal to 22 per cent. of the weight upon the drivers, and high speed is only obtained at the sacrifice of tractive effort. Hence a high-speed freight train is of necessity a lighter train than could be handled over the same profile by a given locomotive, and the crew and maintenance expense is therefore large. That such a class of service is nevertheless profitable, or at least necessary, is evidenced by the continuance of the practice and the proposed introduction of electric locomotives, in effect, makes all trains fast freights, gaining the benefits of such a service, without incurring the penalty of increased operating expenses inherent to steam operation.

Mr. Armstrong does not believe that the time is ripe for the electrification of steam roads at large; indeed, the electrical enthusiasts would be hard put to it if called upon to show reason for the electrification of many branch steam lines carrying a small tonnage at infrequent intervals. There are, however, certain divisions of steam railways which, either on account of their broken profile or heavy traffic, offer an opportunity to introduce a superior type of motive power which will effect such economies in operation as to provide adequate return on the investment required for the electrification. There are still other divisions where a much desired increase in the track-tonnage capacity can only be effected by double tracking so long as the steam locomotive is adhered to as the type of motive power used. Double tracking a mountain-grade division is often a matter of enormous expense, and electrification of the single track may relieve the present traffic congestion at a moderate cost.

On mountain-grade divisions the subject of regeneration with electric locomotives should receive very careful consideration, not so much on account of the saving in power which it may effect, but rather on account of the greater safety of operation, which it guarantees by eliminating the serious defects of holding trains on heavy grades by wheel and shoe friction. No attempt has been made even to approximate the saving effected in engine supplies, roundhouse expenses, elimination of water supply, with its often attendant expensive purifying outfit, and the many items incident to steam locomotive operation. The freight-car shortage problem itself is a very serious one at certain times of the year on some roads, and as the total freight-car mileage can be increased with the higher speeds provided with electric locomotives, it should result in the saving of a considerable expense now incurred for rental of foreign cars, or even increase the gross receipts by the movement of tonnage which more available cars would make possible.

At the conclusion of Mr. Armstrong's paper, the subject was opened for discussion.

Mr. W. J. Wilgus, in a letter discussing the subject, referred to the frequent mistake of overrating the electric locomotive, but expressed the belief that for reasons of economy it had come to stay, even though the primary considerations for its adoption were not economic. Thus far electrification of steam roads has been done for the sake of convenience in operation in tunnels and doing away with smoke and noise nuisances in cities. No practical data were available for basing a change from steam to electricity on purely economical grounds.

Now, however, these data have become available on account of the operation of the two systems side by side on the New York Central, and while the expectations for the electric locomotive have been surpassed by the results, the latter have at times been quite different from the predictions.

Mr. Wilgus stated that his experience indicates that M. Armstrong's figures of cost of current at the contact shoes is too low. In determining this cost not only must the fuel and operating expense be taken into consideration, but also the cost of maintenance, taxes, structures and allied charges for the whole installation.

The experience on the New York Central shows that in maintenance and fixed charges, the electric installation is the cheaper by 19 per cent. The simplicity of the electric locomotive has resulted in a time saving in terminals of 18 per cent. over the steam locomotive, while under the newer system the daily ton-mileage has increased 25 per cent. Of the total switching in Grand Central Station, 65 per cent. with steam locomotives was dead weight, while with electric locomotives it is 54 per cent. In the regular schedule service the saving in dead ton-mileage is 16 per cent.

The total saving of electric operation over steam for the summer months runs from 12 to 27 per cent., depending on the kind of service. In addition, the smoke nuisance has been eliminated in the Park Ave. tunnel, and the capacity of the Grand Central Station has been increased one-third.

Dr. Cary T. Hutchinson, in discussing the paper, expressed approval of the views of Mr. Armstrong and Mr. Wilgus, commending the paper as the best presentation of the problem thus far made. He emphasized the fact that all electrifications now operating have been special problems, aside from the question of economy of operation. The data on electric locomotives are too uncertain as yet for economical discussion of the problem. The regeneration in running down grade with the three-phase system and the consequent fixed speed were the reasons for the adoption of this system on one of the mountain divisions of a Western railroad.

Mr. N. W. Storer emphasized the fact that increased capacity of electric over steam operation is the most important factor of the problem. Electric locomotives can haul heavier loads at greater speeds, up heavier grades than steam locomotives. These factors will count most in causing the electrification of steam roads. The latter work will go on as fast as the manufacturers can supply the equipment, for the data derived from experience are now convincing. The three-phase system, Mr. Storer believed, had a decided advantage in having a fixed speed down grade, but believed that this speed might some times be greater than the curves and roadbed would permit. The single-phase alternating current system has a higher tractive effort at higher speeds than the direct current system. The adoption of the particular system, whether direct current, single or three-phase alternating current, will depend on local conditions.

Mr. W. S. Murray agreed with Mr. Armstrong that capacity is the keynote of the problem, but believed that increase in ton-miles and ability to handle this increase are better ways of expressing it. The actual service conditions on the New York, New Haven & Hartford show a large yearly saving of the electric over the steam locomotives. The machine efficiency of the two can practically be equated and therefore eliminated from the discussion, but the difference lies in the power back of the machine equipments. The saving per year in fuel and locomotive repairs due to electric operation on the New York division will be $562,470.

Mr. William McClellan pointed out that the costs of electrification are larger than were predicted. In order to extend electric operation more convincing figures than even now available must be presented to railroad men. It is difficult to capitalize the savings of electrification due to the abandonment of coaling towers, water tanks, ash pits, and other accessories to steam locomotive operation. Not until a complete engine stage is electrically operated will full and reliable data be available. Leaving these savings aside, Mr. McClellan thought that increased capacity, especially on steep grades, was the most important advantage of the electric locomotive. A good way to approach the problem in endeavoring to convince the railroad man is to show the capacity of electric operation, and then figure the cost for the same capacity if hauled by steam locomotives.

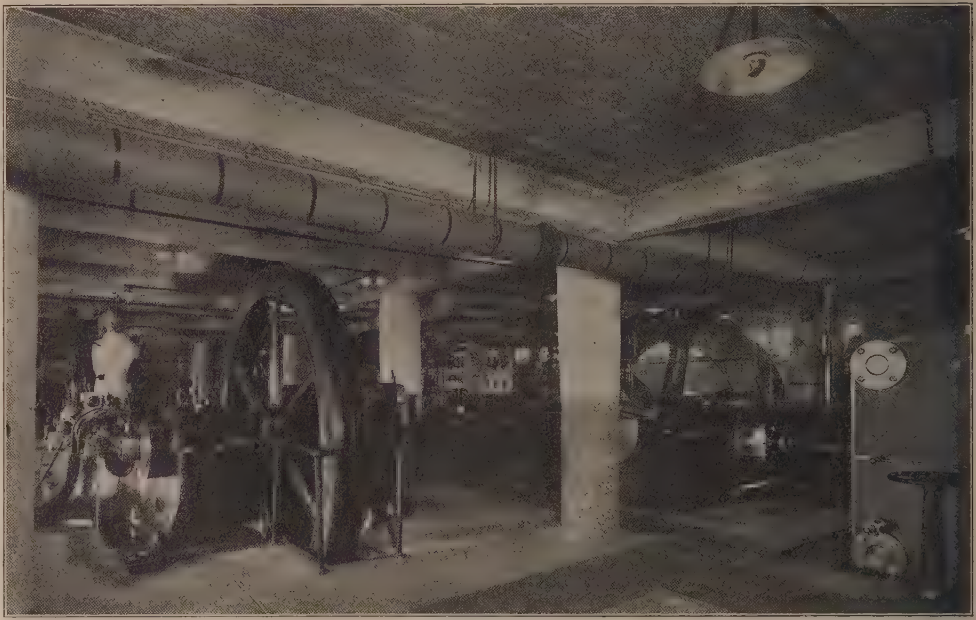
Mr. C. L. De Muralt spoke of a short road that had rached the limit of its capacity, and was considering the addition of two more tracks at a cost of $15,000,000. By electrifying the line at a cost of $3,000,000, the same capacity with the existing trackage could be secured as by the addition of two tracks with steam operation. The advantage of the electric locomotive lies in pulling heavy loads at three to four times the speed of the steam locomotive.

Mr. C. P. Steinmetz pointed out that the use of electric locomotives did not amount to a mere substitution for steam locomotives, but a readjustment of all factors to a new set of conditions. This readjustment must be made throughout the system in order to realize the greatest advantage from the new mode of operation.

Hollow Terra Cotta Blocks will be used for the construction of the floors, interior partitions and roof of the Pennsylvania R. R. terminal, now under construction in New York City.

The Mechanical Equipment of the North American Cold-Storage Building, Chicago.

The North American Cold Storage Co. of Chicago operates a large, modern, fireproof cold-storage warehouse, for public use, on the North Branch of the Chicago River, near the junction of that branch with the South Branch to form the main Chicago River, and a short distance from the central business district of the city. Unlike most large cold-storage warehouses, which cover a broad area and are comparatively low; with the idea of reducing losses due to radiation, this building covers a relatively small area and is very tall, protection against radiation being obtained by thorough insulation of the side walls. The building is irregular in plan, being 60 ft. wide at one end, 80 ft. wide at the other and 162 ft. long, and has sixteen stories and a basement. The structure consists of two parts, an original section and an extension that has recently been added, the two parts forming a homogenous fireproof building with uniform floor levels. The original section has a structural steel frame, covered with hollow tile for fire protection, arched hollow tile floors and brick side-walls. The extension also has a structural steel frame, which is incased in concrete for fire protection, and has reinforced concrete floor slabs. The columns of the buildings are all carried on independent spread reinforced concrete footings, designed to practically float on the soft blue clay that underlies the site.



Engine Room of the Cold Storage Building, Showing One of the Ice Machines.

A mechanical plant in the basement of the building furnishes refrigeration through an ammonia expansion and brine circulation system for all but two floors of the building, the first and the sixteenth, and electric current for power, lighting, freight elevators and other service. This plant was designed and built under peculiarly difficult conditions, owing to the limited head room in the basement, the location of the numerous columns of the building frame, the arrangement and extent of the spread footings which carry these columns, the proximity of the river and the necessity of going below the river level to provide space for boilers. These difficulties were all overcome, however, by special design and arrangement of various features of the plant, and the latter has been in satisfactory operation since the completion of the extension of the building, three years ago.

The mechanical plant and auxiliary equipment occupy the entire basement of the building, a

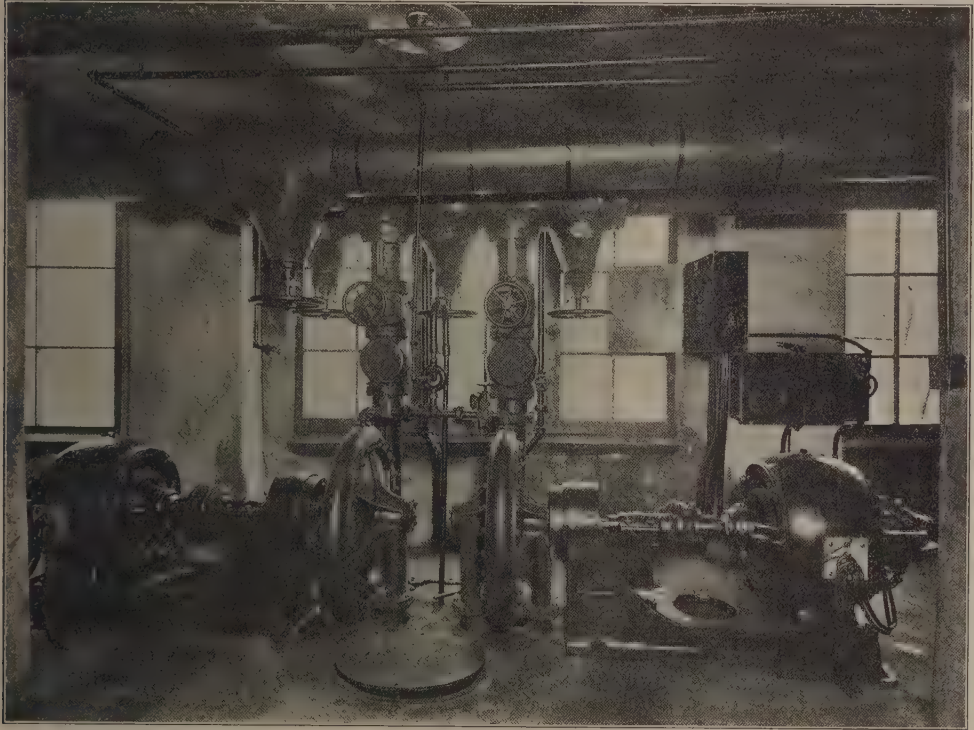
44 x 45-ft. boiler room being separated from the remainder of the basement by brick walls. The floor of this room had to be placed 5 ft. below the water surface in the river, and 12 ft. below the ground level. As the soil is filled ground, black river silt and soft blue clay, provisions had to be made to prevent water entering through the walls and floors. This was accomplished by lining the bottom and sides of the pit with sheet steel, the masonry floor and walls of the room being placed inside of this steel pit.

The boiler room contains two 350 h.-p. double-drum water-tube Cahall boilers, each having 3,750 sq. ft. of heating surface and operating at a normal pressure of 150 lb. Each boiler is equipped with a Cahall chain-grate stoker having 52 sq. ft. of grate surface. These stokers are both driven by a 3 h.-p. Northern motor, mounted on a bracket on one of the columns of the building frame. The motor operates at 450 r.p.m. and is belted to the driving shaft of the stokers. A small steam engine is also held in reserve for operating the stokers. Coal is delivered to the building in cars on a switch track at the first floor level, and is dropped from the cars through chutes leading to a firing floor in front of the boilers. The stokers are supplied from the storage piles on this floor by hand.

The boiler settings extend flush up to the ceiling of the room, the boilers being specially designed so all steam and feed-water connections could be made at the front and rear ends of the steam and water drums. Feed water is supplied to the boilers through duplicate 1½ in. connections at the front. The steam and water drums are also each fitted with an Ashton safety valve, placed horizontally in the upper part of the front end of the drums. The mud drum of each boiler is connected to a 4-in. blow-off pipe, which rises 5 ft. from the floor level of the boiler room to the level of the water surface in the river, so the sediment from the mud drum is blown up-grade. The pipe is fitted with a valve in order that it can be drained into a sump after the boiler pressure is cut off. A 2-in. vertical Kingsford centrifugal pump, with a capacity of 125 gal. a minute when running at 500 r.p.m., removes all water that reaches the sump. This pump is direct-connected to a 1½-h.-p. vertical direct-current Northern motor, which is operated automatically by a float set at the proper height in the sump.

Steam is taken from the rear end of the drums of each boiler by a full-sweep 8-in. connection leading to a 10-in. steam header suspended from the ceiling of the engine room. These 8-in. boiler connections are each fitted with an automatic non-return valve at the boiler and a gate valve at the header. The main header extends 39.25 ft. as a 10-in. main, and then as an 8-in. main for 28 ft., a 6-in. branch being taken off at the end of the 10-in. section. The header is anchored at the junction of the 6-in. branch with it, and all connections to the steam-consuming units have full-sweep bends to provide for contraction and expansion. A Cochrane steam separator is placed on the connection to each unit.

The principal equipment in the engine room embraces two large ice machines, two engine-driven generators, two motor-driven brine-circulating pumps, two motor-driven water-circulating pumps, two boiler-feed pumps, together with the necessary auxiliary apparatus and connections. With the exception of one ice machine, which was in a small plant of the original part of the building, all of this equipment was installed when the new plant was built.


Direct-Connected Centrifugal Pumps for Circulating Water.

The new ice machine is a cross-compound condensing Corliss unit, built by the Vilter Mfg. Co. The steam cylinders are 24.5 x 36-in. and 48 x 36-in., and the ammonia cylinders are 18 and 18 x 36 in. Ammonia is drawn from a large system of condensing coils in one end of the basement and delivered to the seventh and eighth floors by this machine. The old ice machine is held in reserve for use in case the new one is out of commission.

Two double-acting 11 x 12-in. triplex Gould pumps circulate the brine through the system of refrigerating pipes. These pumps each have a capacity of 1,000 gal. a minute against the combination of a static head of 125 ft., and a working pressure of 40 lb. The static head is maintained by an open pipe extending above the highest point in the system of circulating pipes, while the 40-lb. working pressure is the maximum required to force the brine through the system. The pumps are in duplicate, each of them having sufficient capacity to operate the system under maximum service requirements. Each pump is gear-driven by a 50-h.-p. variable-speed direct-current motor, operating at 750 r.p.m. The motor shaft carries a large and a small gear wheel, either of which can be meshed with the gear driving the pump. The small driving gear reduces the speed of the pump to 50 per cent. of that given by the larger gear, and the variable speed control permits the speed of the motor to be changed from one-half to full load; the pumps can thus be operated at as low as 25 per cent. of their rated capacity.

When the extension was added to the building plans were made to install a large electrically-operated butter-renovating plant on the top floor of the building. As the equipment of this plant would require considerable power, a 250-kw. 250-volt direct-current multipolar Northern generator was provided to supply the power necessary for it and for the remainder of the electrically-operated equipment in the building. This generator, which was calculated to carry the day load, is direct connected to a 13 and 16½ x 24-in. high-duty cross-compound condensing Buckeye engine. A 125-kw. 250-volt direct-current multipolar Northern generator, direct-connected to a 10 and 21 x 18-in. high-duty tandem-compound condensing Buckeye engine was installed to carry the night load. The butter plant has not been installed as yet, however, so the 125-kw. unit is used to carry the load at all times.

Circulating water for the surface condenser which serves the steam-condensing units, and for the ammonia condensing coils is furnished by either of two 6-in. horizontal double-suction Kingsford centrifugal pumps, each driven by a 50-h.-p. 250-volt direct-current Northern motor. One of these motor-pump sets operates at 750 r.p.m., and has a capacity of 1,000 gal. per minute, the other, operating at 850 r.p.m., has a capacity of 1,200 gal. a minute. Both of these pumps draw from a 5.5 ft. circular suction well under the basement floor, which has two 10-in. inlet pipes connecting it with the river. Each of these inlet pipes carries a tee connection at the river end in which are placed vertically two 4-ft. lengths of perforated 10-in. pipe, closed at the ends with blank flanges. The perforations in these pipes consist of three ⅜-in. holes per square inch of surface. As the river carries a large amount of silt and sediment these perforations are liable to become clogged, so provisions were made to clear them. A gate valve placed on the well end of the inlet pipes is closed when the perforations are fouled and a current of air under 80 to 100 lb. pressure is forced through the pipes.

The suction pipes of the pumps are not provided with foot valves, but each pump is fitted with a 2-in. connection from the steam header which is used for priming. The discharge for the pumps is arranged so water can be delivered to the ammonia coils and thence to the condenser, or separately to the ammonia coils and the condenser. The discharge from the condenser is returned to the river.

All of the steam-consuming units, except the boiler-feed pumps, are connected to a 16-in. exhaust main, which leads to a 4.5 x 12.5-ft. Blake surface condenser, with a capacity of 15,000 lb. of steam per hour. A 20-in. Cochrane oil separator is placed on this main near the condenser. The exhaust main is also provided with a
pass leading to a free exhaust into the a
phere, a relief valve on this by-pass pro
the exhaust system from excessive pressu

The condensed steam from the condens
livered to a tank, suspended from the
the basement, by either of two 8 x
horizontal marine wet-and-dry Blake
bronze fittings through-out. The s
serves as a hot well in the bo
system. This system includes a
purifier, a Cochrane feed-wate

feed-water pumps. The condensed steam is returned by gravity from the suspended tank to the heater, or directly to either of the feed-water pumps. The make-up water is supplied to the purifier from the city mains through a tight surge tank, a valve operated by a float automatically maintaining the water level in the purifier. Make-up water can be supplied to either pump from the purifier, or directly from the surge tank. The water level in the heater is automatically maintained at one height by a valve operated by a float in the heater. The water level in the heater is also at such height that the pumps draw from the heater until make-up water is required. The heater operates on exhaust steam from the condenser pumps, the feed-water pumps and small pumps which circulate the lubricating oil used in the plant.

A complete system for circulating lubricating oil is installed. Fresh oil is placed in a metal storage tank in the engine room near the boiler feed-water heater. A small reciprocating pump draws oil from this tank and delivers to a supply line connecting with mechanical lubricators on each of the main reciprocating units. Spigots are also placed on this supply line adjacent to the other main units. The drips from all of the units are collected and delivered to a tank in the boiler room by gravity. A second small reciprocating pump draws the dirty oil from this tank and delivers it to a Turner filter over the clean oil tank.

The foundations for the various large machines in the engine room had to practically all be designed specially. The spread reinforced-concrete footings for the columns of the building frame, which are irregular in size and shape, had to be kept separate from the foundations for the machines to avoid vibration being transferred to the building. In order to accomplish this result, a joint at least 1 in. wide was made between the column footings and the machine foundations. The shape and position of the footings required parts of the different machines to be set on heavy I-beams carried over the footings by the foundations; some of these beams also had to be cantilevered over the column footings from the machine foundations. All of this intricate foundation work was done in the basement after the building was completed, the excavations being made in the soft blue clay at about the river level.

The operation of the electrical generators and of the various wiring circuits in the building is controlled from a nine-panel switchboard at one side of the engine room. This board has a panel equipped with an indicating voltmeter and an indicating ammeter, for each generator. A totalizing panel equipped with an indicating ammeter and an integrating wattmeter is also provided. Two power circuits and three lighting circuits are controlled from separate panels, each having an integrating wattmeter. The total output of the generators and the amount of power supplied to each circuit is thus always on record.

The ninth panel on the board carries steam, vacuum, ammonia and back-pressure indicating gauges and recorders, so that all information concerning the operation of the plant is available [illegible] the one board. This panel also carries two [illegible]rically-operated revolution counters, which [illegible] the number of revolutions made by the ice [illegible]es. These counters are operated by an [illegible] on the shaft of the machine, which [illegible]d breaks a circuit including a solenoid [illegible]k of the switchboard, the solenoid hav[illegible]t power to move the works of the [illegible]

[illegible]wo floors of the building, the first [illegible]th, are cooled by the refrigera[illegible]e lowest temperatures are maintained on the seventh and eighth floors, where 4° and 5° below zero Fahrenheit, respectively, can be reached. From the eighth to the fifteenth, and from the seventh to the second floors, the temperatures maintained are successively higher from floor to floor, the normal temperature on the fifteenth floor being 34° Fahr., and that on the second, 32° Fahr. A total of 904,200 cu. ft. of space is thus supplied with refrigeration.

Practically all kinds of food stuffs which have to be stored in cool rooms are placed in the warehouse. Local deliveries to the building and local shipments are made from the first floor by wagons and trucks. Out-of-town deliveries and shipments are also made from the first floor to cars on a switch track at one side of the building. Four electrically-operated Otis freight elevators carry goods from the first floor to every other floor of the building. Two of these elevators are placed in separate fireproof shafts at each end of the building, the shaft connecting at each floor level with a vestibule from which doors open into the cool rooms. These elevators each have an 8 x 10-ft. platform, and a normal capacity of 4,000 lb. With a load of 3,000 lb. all of them have a traveling speed of 150 ft. per minute. One elevator at each end of the building is also arranged with a back gear so it can carry a maximum load of 5,000 lb. at slow speed.

Switchboard and Main Ice Machine, North American Cold-Storage Building.

All power and lighting wire circuits throughout the building are in conduits. The switches on the lighting circuits are in cabinets placed on the wall of the vestibule entrance to each floor from the elevators. The incandescent lamps used in the cool rooms are enclosed in a second glass bulb, thus forming an air space between the two bulbs which largely reduces radiation of heat from the lamps.

The plans and specifications for the mechanical and electrical equipment of the building were prepared by Mr. C. A. Chapman, consulting engineer of Chicago, and the equpiment was installed under his direction.

Forest and Rainfall Relations have been studied for a number of years by Dr. J. Schubert, director of the meteorological section of the Prussian Forestry School at Eberswalde. The observations were made at 17 stations in the forest, on the forest edge and in the open. The forest stations showed the greatest precipitation and those in the open the least, the difference being 5.2 per cent., which is about the probability of error in the results.

Requirements for Treating Wood Paving Blocks.

A paper read before the American Society of Municipal Improvements by Geo. W. Tillson, Chief Engineer of Highways, Borough of Manhattan, New York.

During the last few years wood pavements have attained considerable popularity in this country. Whether they increase or even maintain this popularity depends upon the ability of the blocks to withstand not only the action of street traffic, but that of time and the elements.

Wood has been used at intervals in street pavements for about seventy years, but never with any permanent success, if we except the present movement. This being so, it can pertinently be asked why should any better result be expected now. The answer is that there is one vital difference between the old and the present blocks, as the former were laid in a natural state while the latter are treated chemically.

Pavements wear out or rot out. If their material will not decay, the life varies according to the traffic imposed upon them. But wood in its natural condition is subject to decay and with no traffic at all will last only for a limited time. The object of the treatment then is primarily to prevent this decay. But all wood swells when exposed to moisture and contracts when subjected to heat. But if the pores of the wood can be filled with a substance that will prevent the absorption of water it can be kept stable in size, neither shrinking nor expanding during the varying changes in the weather. The object then of the introduction of chemicals is to prevent natural decay and maintain stability in size, so that a pavement will not bulge wet nor be full of loose joints when dry.

The question, therefore, is how can these objects be attained. It is generally admitted that the best agent for treating blocks is creosote oil. When the city of Indianapolis some eight or nine years ago began to lay treated wood pavements, it required the blocks to be first thoroughly dried and then impregnated with creosote oil weighing 8.8 pounds per gallon and to an amount equal to 10 lb. per cubic foot. But it is probable at that stage of the business not enough attention was given to the character of the oil or the actual quantity used, so that the first pavements buckled to quite a serious extent. The possibilities of a perfect wooden pavement were appreciated, however, and eventually successful pavements of this character were laid.

Some time later an Eastern firm took up the matter of treating wood blocks and instead of creosote oil alone, using a mixture of 50 per cent. oil and 50 per cent. rosin, and 20 lb. per cubic foot. The first pavement of this character was laid in Boston, on Tremont St., in 1900. I quote herewith from a letter received last month from an engineer in the Boston Street Department as to its present condition.

"I have just been and looked at the wood paving on Tremont St. About three years ago the upper end, perhaps a hundred feet long, was taken up and relaid with the old blocks, with open joints about the thickness of a lath, and grouted with cement and sand, as I remember it. That portion shows wear, the joints have widened and there is some irregularity of surface. The remainder looks very well. On the part most worn, that is near the middle of the street, there is a somewhat rolling surface.

"The pavement was laid in 1900, and it has worn very well indeed as a whole and is now in good, usable condition."

This is, without doubt, the best evidence that can be obtained upon this particular kind of pavement. In 1902 a street was paved with this material in the Borough of Brooklyn, New York. In addition to the above, the specifications required that the blocks, when treated, should sink in water, and after having been subjected to a temperature of 100° F. twenty-four hours, should not absorb more than 3 per cent. of water when immersed for an additional twenty-four hours, the idea being to specify a result rather than a method only. The absorption test was considered the most important, the other being preliminary only and an indication that the proper amount of the mixture had been used. No trouble was ever experienced with pavements laid by the city under these specifications.

As the use of wood spread over the country, different specifications were adopted according to the views of the different officials. Bearing in mind the objects to be attained by the treatment, the method that will produce that result economically is the best. With the constantly increasing price of all materials used in the production of treated blocks, it is of great importance that no surplus nor unnecessarily expensive material be used. The Borough of Manhattan, New York, probably has more of this treated pavement than any city of this country, and the salient points of the specifications under which the latter portions of them was laid are here given.

(4.) The blocks are to be treated throughout with an antiseptic and waterproof mixture, 75 per cent. of which shall be creosote or heavy oil of coal tar conforming to the specifications hereinafter set forth, and 25 per cent. of which shall be rosin conforming to the specifications hereinafter set forth. All parts of each individual block shall be thoroughly treated, and not less than twenty (20) pounds of the mixture per cubic foot shall be injected.

(5.) In preparing the blocks to receive the creosote mixture, they shall be placed in an airtight cylinder, in which dry heat, or heat produced by superheated steam, is maintained and raised to a temperature of 215° F., for one hour, for the purpose of expelling moisture; the heat is then to be increased until it has reached 285° F., this heat being maintained for a period of three hours, or until the block is completely sterilized. Application of heat is then to be stopped and the temperature of the cylinder allowed to fall for one hour, or until same has been reduced to 250°. A vacuum is then to be applied until about 26 in. is reached, and while under this vacuum the creosote mixture is to be run into the cylinder at a temperature of from 175° to 260° degrees, after which hydraulic pressure of not less than 200 lb. per square inch is to be maintained and raised until the individual blocks are treated throughout.

(6.) The creosote oil is to conform to the following specifications when tested, as follows:

(7.) The gravity at 68° F. shall be not less than 1.12. When distilled in a retort with the thermometer suspended not less than 1 in. above the oil, it shall lose not more than thirty-five (35) per cent. up to 315° C., and not more than fifty (50) per cent. up to 370° C. The oil is to be free from adulteration; it must not be mixed with or contain any foreign material.

(8.) The resin is to be solid resin obtained from pine. It is to be reduced to a fine dust by grinding and then incorporated with the hot creosote oil in a suitable mixing tank until the proper proportions are secured.

(9.) After treatment the blocks are to show such waterproof qualities that after being dried in an oven at a temperature of 120° for a period of twenty-four hours, weighed and then immersed in clear water for a period of twenty-four hours and weighed, the gain in weight is not to be greater than three (3) per cent.

(40.) Fine turnings from the block shall be placed in a suitable extraction apparatus and the oil completely extracted therefrom with ether or carbon bisulphide. The oil so extracted shall be placed in a suitable still and distilled. The portion up to 120° C., consisting of the solvent, is to be collected apart. The oil shall then be distilled up to 370° C. The creosote oil thus obtained must conform in all respects to the requirements of paragraph 39, subdivision 7.

(41.) The Engineer shall have tests and examinations made at the contractor's works of the materials and blocks proposed to be used, and reject any or all of such materials and blocks as he may consider not to be in compliance with the specifications. The Borough President shall appoint an inspector at the expense of the contractor, who shall inspect the lumber and other materials used in the manufacture of the blocks, and the treatment of the blocks; and he shall reject any of such material and blocks as he may consider not to be in compliance with these specifications.

(42.) The blocks will be carefully inspected after they are brought on the line of work, and all blocks which in quality and dimensions do not conform strictly to the requirements will be rejected and must be immediately removed from the line of work.

It will be noticed that the rosin used is only 25 per cent. and the specific gravity of the creosote oil is 1.12 which would give a weight of 9.4 lb. per gallon as against 8.8 lb. as in the original Indianapolis requirements.

In revising these specifications the writer modified them by specifying that the mixture used should contain not more than 75 per cent. of oil and not less than 25 per cent. of rosin, that pine blocks should weigh as much as water, black gum blocks 59 lb. per cubic foot and any other kind of wood at least 20 lb. per cubic foot more than the untreated. Also that the blocks should not absorb more than 3½ per cent. of water after having been dried for twenty-four hours at a temperature of 100 deg. Fahrenheit. He also changed the wordings of the clause stating the exact method of treatment by making it general in nature, so that a contractor can use any method he pleases provided that he uses the proper material in proper quantity and produces a specification block.

The words "not more" and "not less" were inserted because the author believes that with a correct proportion of rosin and oil there will be no trouble in making a block that will fill the requirements of the specifications. The weight requirement was made so as to ensure as certainly as possible that at least twenty pounds of the mixture is used. This is probably approximate only, but undoubtedly useful.

The writer was probably the person who first proposed the absorption test, and the preliminary drying was not only intended to drive off some of the contained moisture, but also to test the volatility of the oil used, and the idea was to subject it to a temperature that would produce a result equal to actual use. It was also believed that an absorption of 3½ per cent. was sufficiently severe.

In order to ascertain the present practice the writer has compiled from the specifications of the cities mentioned in the accompanying table the salient points regarding treatment and tests. The table represents the general practical differences of the cities in this country and can be considered as representative requirements.

It will be noticed that all of the specifications require creosote oil, and Indianapolis is the only one that does not require it to be mixed with something else. The Brooklyn specifications vary a little from the others in that they allowed as a substitute for resin "or any other suitable waterproofing material." One contract was laid with material other than resin, and up to the present time, although only three years have elapsed, the pavement has been satisfactory.

It should be the object of all engineers to reach the desired results in as economical a way as possible, and if 25 per cent. of resin is as good as 50 or, if none at all is necessary, it should be left out, as the addition of the resin makes quite an increase in the cost. It will be noticed also that all the cities but Minneapolis require 20 lb. of material per cubic foot, where Minneapolis calls for only 16. Of course, if 16 lb. are as good as 20, there is no necessity for putting in the extra 4 lb.

	Mixture				Tests	
City	Character	Pounds per Cu. Ft.	Specific Gravity of Oil	Kind of Wood	Weight	Absorption
Boston	Creosote oil 75 Resin 25	20	1.12	Long leaf yellow pine Southern black gum		3
Borough of Brooklyn	Creosote oil 50 Resin 50	20		Long leaf yellow pine	Greater than water	3
Indianapolis	Creosote oil	20	1.12	Long leaf yellow pine		
Minneapolis	Creosote oil 50 Resin 50	16	1.09	Long leaf yellow and Georgia pine; Norway pine; Washington fir; Tamarac		
Borough of Manhattan	Creosote oil 75 Resin 25	20	1.12	Long leaf yellow pine; Southern black gum; Norway pine; Tamarac		

It will also be noticed that, while the specific gravity of the oil called for in Boston, Indianapolis and the Borough of Manhattan is 1.12, no specific gravity is given for Brooklyn, and Minneapolis calls for 1.09. It can be said regarding the Brooklyn specifications that they were made several years ago, when the question of the oil was not as well understood as it is at present, and no wood block has been laid in Brooklyn for the past three years.

The question of the kind of wood also makes a difference in the treatment. All of the above specifications allow long leaf yellow pine; three allow Southern black gum, and the Minneapolis allow, in addition, Norway pine and tamarac, while Minneapolis also permits Washington fir. It can be easily understood that black gum, tamarac or fir, woods that contain no pitch of themselves, should require a different treatment than yellow pine. It will also be noticed that the only test specified for the blocks after they are treated is that Brooklyn requires the blocks to be heavier than water, and Boston, Brooklyn and Manhattan require that they shall not have an absorption of more than 3 per cent. of water after having been dried for 24 hours and then immersed in water for an additional 24 hours.

The question of the specific gravity of the creosote oil is very important, and in order to learn something about the difference in the volatility of oils of different specific gravity a test of evaporation was made by the chemist of the Bureau of Highways, Borough of Manhattan, with the following result:

The experiment was carried out as follows: Approximately 50 grams of each oil was placed in an open cylindrical vessel having a diameter of 3 in. and 1¼ in. high. The oil was then subjected to a constant temperature of 120 deg. Fahrenheit for a period of 50 days, the oil being frequently weighed, as shown in the table below.

Four samples of oil were selected for these tests, two having a light specific gravity and two heavy oils. These oils when subjected to distillation had the following constitution:

	Creosote Oils			Distillate	
No.	Specific Gravity	To 315° C Per Cent.	315°-317°C Per Cent.	Total to 370° C Per Cent.	Residue Per Cent.
S— 997	1.055	82.5	8.5	91.0	9.0
S—1003	1.180	33.4	13.4	46.9	53.2
S—1008	1.065	83.1	8.5	91.6	8.4
S—1017	1.190	35.4	10.9	46.3	53.7

The amount in weight which these oils lost when maintained at 120 deg. Fahrenheit, in the number of days indicated, is shown in the following table:

CREOSOTE OILS.—Loss in Weight at 120 deg. F.

	S-997	S-1003	S-1008	S-1017
No. of Days	Sp. Grav. 1.055 Total Loss Per Cent.	Sp. Grav. 1.180 Total Loss Per Cent.	Sp. Grav. 1.065 Total Loss Per Cent.	Sp. Grav. 1.190 Total Loss Per Cent.
1	13.3	6.2	10.9	3.8
2	20.2	8.1	18.2	5.7
3	26.8	10.7	24.2	7.4
6	41.1	13.3	39.1	9.9
10	53.1	16.0	49.7	12.1
15	58.9	18.1	54.4	15.0
22	63.4	19.1	59.1	15.8
29	67.0	19.6	61.9	16.2
36	69.1	20.3	64.1	16.7
43	70.9	20.8	66.1	17.3
50	72.3	21.2	67.5	17.6

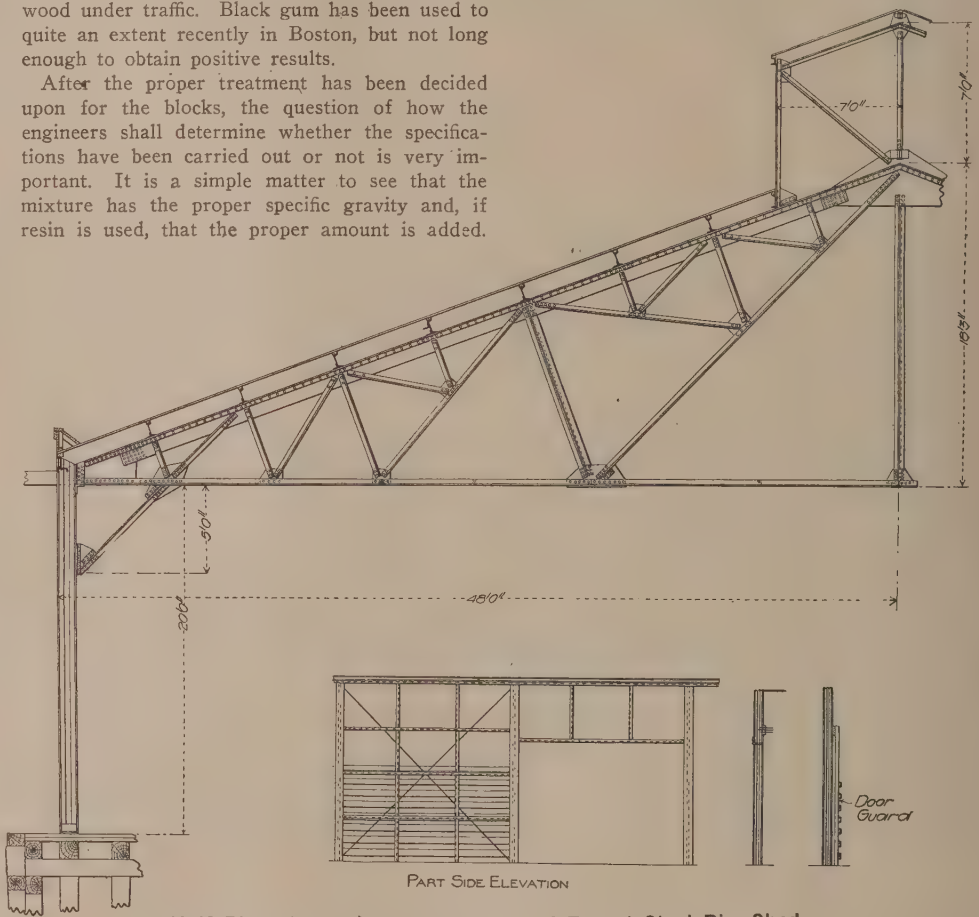
It will be noted that there is a great difference in the evaporation of the oils, both under high temperature and also the extended test of 50 days. Under the 50-day test, subject to a temperature of 120 deg. Fahrenheit, the oil with a specific gravity of 1.055 lost 72.3 per cent. of weight, while the oil with a gravity of 1.19 lost only 17.6. It must also be understood that a so-called creosote oil, with a specific gravity of 1.19, is an entirely different material from one with a specific gravity of 1.055; and it is questionable if, with the heavy oil, it is necessary to have the 50 per cent. of resin, or any at all. In fact, a great many engineers contend that the addition of the resin is injurious rather than beneficial. The object of the resin, theoretically, is as much, if not more, to preserve the creosote oil and maintain it in the blocks as it is to act as any preservative itself.

Referring to the different kinds of wood, the writer believes that it would be difficult to obtain an absorption of 3 per cent. or less with any of the non-pitch woods with so small an amount of oil as 20 lb. per cubic foot. A sample of black gum that had been kept in an office, under the ordinary temperature, for a year or more, that had been treated with 40 lb. of oil per cubic foot, was tested for absorption, under the usual conditions, and absorbed less than 2 per cent. of water.

All engineers will probably agree that the yellow pine wood of itself is the best material that can be used. But this material is growing scarcer and more expensive every year, and the government officials have been making experiments for some years, with the idea of obtaining other woods that would be equally as good, if possible. If, however, in order to get good results it is necessary to use more oil than with the pine, it might bring the cost of the cheaper woods equal to the cost of more expensive woods after both had been treated.

The 20-lb. treatment will cost approximately 45 or 50 cents per square yard for the mixture, and if an additional 20 lb. are added it, of course, increases the cost directly that amount. So that, at the present prices, with the same treatment, black gum has an advantage over the yellow pine of about 45 cents per square yard. This difference, however, might be more than overcome by the durability, or rather lack of durability, of the wood under traffic. Black gum has been used to quite an extent recently in Boston, but not long enough to obtain positive results.

After the proper treatment has been decided upon for the blocks, the question of how the engineers shall determine whether the specifications have been carried out or not is very important. It is a simple matter to see that the mixture has the proper specific gravity and, if resin is used, that the proper amount is added. The quantity of blocks put in the retort can be ascertained and the proper quantity of mixture used, so that the blocks will average the proper quantity per cubic foot. Of course, it will be impossible to be sure that each block has the required amount. When it comes, however, to applying the absorption test and the weight of the block, if that be specificed, another question comes up; that is, whether the blocks shall be tested at the works when they are just completed or at some subsequent time when delivered on the street, which may be some weeks or, very probably, in some cases, months. The contractors claim that the test should be made at the works and, if satisfactory, then they should be accepted at any time afterwards.



Half Elevation of Transverse Bent of Export Steel Pier-Shed.

As the blocks are to be used in the streets for years, it would seem that they should be treated in such a way that they would stand the required test, even if not used for several months after having been treated, especially if heavy oils have been used and in the light of the experiment noted above. The heaviest oil lost, approximately, 18 per cent. after having been subjected to a temperature of 120 deg. for 50 days, which is an extremely severe test and one never possible to be reached on the street. If a block had been treated with 20 lb. per cubic foot and had lost 18 per cent. it would still have 16.4 lb. per cubic foot of the original mixture, which is more than the original requirements for the Minneapolis specifications. It would seem, therefore, to the writer, conclusive that the blocks should conform to the specifications when delivered on the street and not when treated.

The requirement for sinking in water, which was inserted in the Brooklyn specifications, was used more to give a quick test than for anything else, and it was found that if the pine blocks which were treated with a material that contained 50 per cent. of creosote oil and 50 per cent. of some other suitable material, almost every block that would sink in water would conform to the requirements in regard to absorption. This, however, in later experiments has not been found to be true, and, in many cases, blocks that would sink in water have not conformed to the absorption test. This may have been because the blocks were heavier originally; they did not take the treatment and absorb as much oil as the other blocks, and that when immersed in water would absorb more water. This is wholly speculative, however.

The writer believes that the question of treating wood paving blocks is one that is being investigated more at the present time than any other one kind of pavement, as he has received many inquiries regarding it during the past season. He also believes that it is a matter that neither engineers nor contractors have any positive knowledge of at the present time, and thinks it of great importance that the different cities investigating the matter should, in some way, give each other the result of their different investigations, so that in the end all cities might arrive at a good and satisfactory specification.

The question of testing the blocks is one of great importance, and it is absolutely necessary to arrive at some method of making the tests that will be as nearly positive as possible and perfectly satisfactory. And the object of writing this paper has been, not so much to give information as to seek it and, if possible, to bring about the consummation above mentioned; that is, the getting together the ideas of the different engineers of the various cities and finally reach a result that will be satisfactory to all.

An Export Steel Pier-Shed.

The new deep-water pier for the Insular Dock Co., in San Juan Harbor, Porto Rico, is 420 ft. long by 100 ft. wide over all and has a wooden pile sub-structure and a steel superstructure. The design is of an ordinary type, and the construction is simple and is intended to adapt standard features and practice to the local conditions and the requirements for shipment. It is therefore interesting, not for novel or unusual construction, but as an example of a class of work likely to be undertaken in increasing amounts by American engineers and contractors.

The pier is located in a sheltered harbor, where there is a tide of 1 ft., and it is not exposed to unusually severe winds or to especially heavy impact from adjacent navigations. The substructure is made with yellow pine creosoted piles about 70-80 ft. long, driven through 50-60 ft. of water and soft mud to hard bottom. They are arranged in transverse bents 10 ft. apart on centers, with 23 bearing piles in each bent, all of which, except the three at each end, are 5 ft. apart. There are also two spur piles and two fender piles in each bent. The piles are capped with longitudinal 12 x 12-in. rangers, with butt joints, and 6 x 12-in. double side plates between bents. The piles are connected transversely by a pair of 6 x 12-in. horizontal ledger pieces at the top of each bent just below the longitudinal timbers. The floor is made with 4-in. transverse planks covered with 4 in. of concrete.

The 96 x 400-ft. steel shed is symmetrically located on the pier and has a height of 50 ft. 3 in. over all. It is made with 21 transverse bents, 20 ft. apart, connected with 21 lines of longitudinal purlins, two lines of longitudinal struts and nine sets of lateral X-bracing in alternate panels in the planes of the rafters. At one end of the shed there is a two-story house, two panels long, for office and administration purposes, and the remainder of the building is one story in height, with a monitor 7 ft. high and 14 ft. wide on the center line of the building, occupying 17 panels in length.

Each transverse bent has a triangular riveted main roof truss, 18 ft. 3 in. deep in the center, which is knee-braced and rigidly connected to the tops of the wall columns, 20 ft. high. The top chord or rafter has a T-shaped cross section made with a pair of 4 x 3½-in. flange angles and a 12-in. vertical web plate, to which the single and double angles forming the other members of the truss are riveted direct without connection plates, except at the feet and at the eaves. The truss members are to be shipped separate and field-riveted together in a horizontal plane on the ground and erected by derricks.

The columns have an I-shaped cross section and a horizontal base plate, bolted directly to the floor timbers. The trusses are connected by longitudinal struts at the peak and at the foot of the center vertical and by 18 lines of 7-in. channel purlins, bolted to angle clips on the top flanges of the top chord. Knee-brace plates riveted to the upper lines of purlins and to the top chords of the trusses serve also as connection plates to receive the feet of the verticals in the monitor frames at panel points. Intermediate monitor frames are connected directly to the purlins and carry three lines of 4-in. channel and I-beam purlins. All purlins have 2 x 3-in. nailing strips bolted to their top flanges to receive the 1¼-in. sheathing boards parallel to the top chords, which are covered with the ordinary tar, felt and gravel roofing.

A wooden gutter is formed at the eaves by a sort of fascia or cornice board flashed with the roofing. The eaves purlin has an L-shaped cross section made with two channels, one vertical and one horizontal, the latter serving as a frame for the siding and door casing. The fifth purlin from the eaves on each side is reinforced from end to end of the building by a 3 x 3 x ¼-in. angle riveted to the web of the channel to stiffen it for the longitudinal countenance of the lateral stresses. The lateral diagonals are 1-in. rods, with screw ends and nuts bearing on beveled washers.

The walls of the building are sheathed with corrugated iron, secured to studs and girts made respectively with 6-in. vertical channels and 2 x 2 x ¼-in. horizontal angles. The shore end is made special, with intermediate columns for the two large doors, and with an extension for a false front above the roof line. Between the one-story and two-story parts of the structure there is a special junction bent made with a horizontal 12-in. channel running across the full width of the building at the height of the eaves, 20 ft. above the floor, and supported by five intermediate columns. The side walls of the one-story part have six full-width doors, one in every third panel, with two windows above each door. In eight panels between the doors there are ⅞-in. round X-brace rods, corresponding in seven cases to the lateral bracing in the roof. In two of the center panels the diagonal bracing occurs where there is none in the corresponding roof panels.

Between the large side doors the inner faces of the columns are protected by freight fenders, consisting of eight horizontal lines of 2 x 8-in. planks, 8 in. apart, spiked to 3 x 4-in. vertical studs furred out 4 in. from the column, forming a pocket for the sliding doors. In the shore end of the building there are two large doors, two small doors and sixteen windows. At the river end there is one 14 x 16-ft. center door and one large window in the monitor. Most of the space in the side walls of the monitor is occupied by Berlin louvres, without glass. The total weight of structural steel is about 550,000 lb. The contract for the pier and shed was awarded to John Monks & Sons, New York; Mr. Richard A. Monks is the company's engineer on the dock, and Mr. John W. Ripley, engineer on the shed. The steel work was furnished by the Dietz-Waring Co., of New York.

A 1,200-FT. DOUBLE CABLEWAY for hauling coal and shale across a valley has been installed by Messrs. R. White & Sons, Widnes, England. There are four spans in all, the intermediate towers being 12 to 30 ft. high. The grades of the rope vary from 1 in 6½ to 1 in 2, the slope being upward against the loads. The loading terminal is about 10 ft. from the top of the colliery shaft, and a track runs from the latter to the loading terminal, sloping rapidly downward beyond the point, where the cableway picks up the cars. The latter weigh about 400 lb. each and carry a load of 800 lb. They are attached to the cableway carriers by stirrup-irons, which go under the box of the car. On reaching the discharge end they take the ground on a rising grade, exactly opposite to the arrangement at the loading end, and when on the level are automatically detached from the hauling rope. The small cars are dumped into railroad cars and sent back to the loading point on the return cableway rope. At the discharge end a tension-wheel is mounted on a trolley, which runs on a short track to take up the slack. The maximum capacity, according to "Engineering," of London, is 70 tons per hour.

The Sterilization of Treated Sewage.

At the present time there are few subjects more interesting to those engaged in research work in sanitary engineering than the sterilization of the effluents of sewage disposal works. The subject can hardly be termed one of immediate practical importance, except in a very few places, like Baltimore, where the existence of a great shellfish industry has made it obligatory to ensure an unusual degree of purification of the sewage before its discharge into Chesapeake Bay. In fact, the importance of sterilization will depend very largely on the results which may be reasonably expected from it and the cost of attaining these results, both of which factors remain to be determined. An instructive paper on the subject by Messrs. Phelps and Carpenter was printed in this journal on Jan. 19, 1907, and in the present article it is proposed to give an outline of investigations made by Messrs. Karl F. Kellerman, R. Winthrop Pratt and A. Elliott Kimberly, and described in a recent bulletin of the U. S. Bureau of Plant Industry.

Experiments upon the germicidal effect of copper were planned to include sewage effluents of different qualities, ranging from highly purified effluents from sand filters to the putrescible effluents from septic tanks. Westerville, the Boys' Industrial School, Lancaster, and Marion, Ohio, were selected for sub-stations, and a preliminary experiment upon fresh sewage was conducted at St. Mary's of the Springs, near Columbus, Ohio.

St. Mary's. St. Mary's of the Springs is a convent school of about 175 persons. The sewage is discharged into two tanks operated in series. These tanks are 10 ft. in diameter and about 6 ft. in depth to the flow line. Recent measurements indicate that the flow of sewage is in the vicinity of 12,000 gal. for a period of 16 hr., there being practically no flow after 10 o'clock p. m. The highly putrescent sewage discharges from the second tank into a small brook. It has been the daily practice of the health department of Columbus to apply copper sulphate to the sewage at the inlet of the second reservoir. The sulphate in a dry state is placed in a perforated pail, which is lowered into the liquid to a point opposite the discharge pipe from the first reservoir. The sulphate remains suspended here, exposed to the somewhat erratic solvent action of the incoming sewage; at times it is found that the entire quantity of chemical used for one day's dose is not completely dissolved in 24 hr. In making an examination of this plant samples of untreated sewage entering the second tank and of treated sewage leaving the second tank were collected at half-hourly intervals for a period of seven hours on two successive days.

From an average of 16 samples of effluent collected on two days the total number of bacteria to the cubic centimeter developing within 48 hr. at 20° C. was 5,600,000 for the raw and 65,000 for the treated sewage, giving a reduction of approximately 99 per cent. Platings of the treated effluent when incubated at 37° C. for a period of 24 hours averaged 250,000 colonies, of which 36,750, or 14.7 per cent., were acid-producing, the majority being *Bacillus coli.*

The cost of treating the settled sewage is practically the cost of chemicals and the cost of maintenance, as the construction costs for the plant are practically negligible. With copper sulphate at 6 cents a pound and a daily sewage flow of 12,000 gal., the expenditure for chemicals is 3 cents for each 1,000 gal., using 6 lb. of copper sulphate a day. The labor cost may be considered to be 25 cents a day. Similar plants applying copper sulphate in the proportion of 63 parts to the million to a sewage flow of 12,000 gal. would require about 6 lb. of copper sulphate daily, costing 36 cents a day. On an annual basis the chemical and maintenance cost would be about

$222.65. Capitalized at 5 per cent., this would represent an investment of $4,500.

For crude sewage much better results could probably be obtained by using 100 parts of copper sulphate to each million parts of sewage. For treating 12,000 gal. of sewage at this rate the expense would be 60 cents a day, or $310.25 annually, and the corresponding capitalization would be $6,200.

Westerville. The sewage plant at Westerville, Ohio, comprises two small septic tanks, which discharge, through an aerating device, onto six primary cinder filters, which in turn discharge upon two secondary filters. The plant at the present time is operated continuously, instead of upon the contact principle. The effluent from the primary filters is usually non-putrescible, but at times tends to become unstable and contains considerable crude organic matter. As the effluent from the primary filters was the more accessible, by suitable piping it was conducted through an orifice box, where the proper quantity could be diverted for the experiments with copper treatment, the excess being discharged over a waste weir.

The copper crystals were dissolved in barrels and conducted to an orifice box, where a constant head was maintained upon an adjustable orifice. The quantity of copper sulphate used in each test was based upon the computed flow of 41,000 gal. of effluent in 24 hours. At the point of entrance of the sewage effluent and the copper solution there was a small longitudinal baffle, serving to effect a thorough mixture of the chemical and the effluent. The time of contact of sewage and sulphate was slightly over one hour. It was the general practice to apply copper sulphate at a given concentration for two consecutive days.

At hourly intervals during the test bacterial samples of the sewage effluent were collected before and after treatment. Samples for chemical analyses were collected at hourly intervals, and the composite sample so obtained was subjected to chemical analysis. In addition, determinations were made in the field for free carbonic acid and for alkalinity before and after treatment.

The percentage of removal of bacteria grown at 20° C. varied from 95 to 59 per cent., depending upon the concentration of copper sulphate applied and also upon changes in temperature. The removal of bacteria developing at 37° C. was much more erratic than was the case at 20° C., the percentage of removal varying between 28 and 96 for total numbers and between 66 and 100 for acid-producing bacteria.

On the basis of treating daily 41,000 gal. of effluent from the primary contact filters, the initial cost of a plant for applying the germicidal chemical would be $70 in round numbers. Considering a satisfactory removal of pathogenic organisms to be produced by a concentration of 40 parts to the million, the daily quantity of copper sulphate required would be 13.7 lb.; the cost for chemicals would be about 82 cents, and for 2 hours' labor, 50 cents. The annual cost, with copper sulphate at 6 cents a pound and labor at 25 cents an hour, would then be $482.50. Capitalized at 5 per cent., this would represent an investment of $9,650.

Boys' Industrial School. The Boys' Industrial School is a State institution near Lancaster, Ohio, and has about 1,100 persons. The sewage is treated on 23 intermittent sand filters, which receive the crude sewage, which has been subjected only to rough screening as a preliminary treatment. The flow averages about 160,000 gal. in 24 hours. It was thought most practicable to apply the chemical to the entire effluent flow, carrying out the experiments with a view to learning the quantity of copper sulphate required to destroy coli-like organisms when the effluent was flowing at a maximum rate.

The quantity of copper sulphate applied at the beginning of the test was calculated to afford a concentration of 5 parts to the million. The rate of flow of the copper solution was practically constant at 0.75 gal. a minute, but the flow of the sewage effluent varied widely; consequently, the resulting concentration of copper sulphate showed the same variations. The concentration of copper sulphate applied was increased on each successive run until a maximum of 20 parts to the million was reached, based on a flow of 150,000 gal.

From the public health standpoint the treatment at Lancaster was more satisfactory than either of the two preceding cases. The more efficient action of copper sulphate at Lancaster is undoubtedly due to the better chemical condition of the sewage effluent, especially its greater freedom from organic matter and its freedom from carbonates.

The daily application of copper sulphate to the Lancaster sand filter effluent, with its flow of 160,000 gal. a day, would require 17.3 lb. of sulphate, and the cost of this chemical would be about $1.04 a day, based on applying 13 parts of copper sulphate to each million gallons of effluent.

The cost of constructing the Lancaster plant used in these experiments and capable of treating sewage at the rate of 160,000 gal. for six hours was $29. However, a fair estimate of the cost of a plant under practical conditions for continuous treatment would be about $92. The maintenance cost per annum on the above basis would be $1,109.50. Capitalized at 5 per cent., this would represent an investment of $22,000.

Marion. The sewage disposal plant at Marion, Ohio [Eng. Record, March 17, 1906], is a combination of septic tanks, contact filters and sand filters, handling about 600,000 gal. of sewage daily. The storage or contact period of sewage effluent and copper sulphate was determined to be about one hour. The solution was discharged at the rate of 2 gal. a minute.

At the present time the disposal plant is hand-operated in the daytime only, and it was during such normal operation that the copper experiments were carried out. From 7 o'clock a. m. until 10 a. m. practically no water is discharged into the effluent channel; hence all of the tests began at about 10 a. m. Samples were collected at half-hourly intervals.

The results of these experiments are somewhat disappointing. The degree of bacterial purification did not equal that obtained at Westerville, and, as at Westerville, a great increase in the quantity of copper sulphate applied caused but slightly increased efficiency. The chemical condition of the effluent at Marion was somewhat similar to that at Westerville, but the time of contact with copper sulphate was much shorter. As several investigators have shown, time of contact is a very important element in the germicidal action of copper, and the low bacterial removal is probably due to this factor.

The application of copper sulphate to the Marion sand-filter effluent, with a daily flow of 600,000 gal., on a basis of applying 20 parts of copper sulphate to each million gallons of effluent, would cost $6 a day for chemicals, and the cost of constructing a plant for applying the copper sulphate would be about $151. The cost of treatment annually on this basis would be about $2,920. Capitalized at 5 per cent., this would represent an investment of $58,000.

After completing the experiments with copper sulphate it was decided to experiment with the use of chlorine. In the case of certain hospitals it may be desirable to disinfect the crude sewage discharged from them, and this may be done satisfactorily by means of chlorine, without interfering with the subsequent biological phenomena of purification. Generally speaking, however, the proper function of germicides in dealing with a large quantity of sewage is that of improving the biological character of the previously chemically purified effluent. This chemical purification may be only partial, as in the case of the effluent from septic tanks, or complete, as in the case of a high-grade sand-filter effluent.

As the most inexpensive and practical source of chlorine for the experiments, calcium hypochlorite or bleaching powder was selected. This costs upon an average about 3 cents a pound, and in large quantities may be purchased for 2½ or 2¾ cents a pound. The strength of the commercial chloride of lime in bulk varies widely and, according to analyses of the commercial product purchased in Columbus, Ohio, ranges from 18 to 25 per cent. of available chlorine. The data of cost have been calculated on the basis of 2½ cents for a grade containing 25 per cent. of available chloride.

According to the experience gained at Lancaster and Marion, the preparation of the hypochlorite solution is an important feature in the successful chlorine treatment of sewage effluents. It was found that unless special precautions are taken in dissolving the bleaching powder, many large lumps which inclose chlorine remain and materially reduce the efficiency of a given weight of bleaching powder.

The method of preparation found to give the best results is as follows: A weighed quantity of bleaching powder is placed in a shallow box and covered with sufficient water to form a smooth paste. More water is then added until the heavier particles settle out, thus allowing the soluble and finely divided chloride of lime to be decanted. After decantation more water is added, the coarse lumps are broken up, and the process repeated until as much as possible has gone into solution. The importance of thoroughly mixing the chloride of lime solution and of grinding the dried chloride as fine as possible cannot be too strongly emphasized; otherwise a loss of from 10 to 30 per cent. may take place, especially in the case of low-grade bleaching powder.

Boys' Industrial School. The leading results obtained during the first series of chlorine tests at Lancaster indicated that the removal of coli-like organisms was practically 100 per cent., and the removal of total organisms, 99.8 to 99.9 per cent. In organic compounds the effluent under treatment was substantially similar to that found during the copper experiments, and the temperature of the effluent was practically at the maximum density of 4° C. In practically all instances by means of the iodo-starch tests residual chlorine was detected in the discharge after a storage of about three hours. The solution was discharged into the sewage effluent at the rate of 0.75 gal. a minute, and variations in the quantity of chlorine applied were made by changing the strength of the hypochlorite solution.

The cost of constructing a plant for treating the sand filter effluent of the Boys' Industrial School with chlorine may be taken at $92. Substantially the same plant could be used as in the case of treatment with copper sulphate. The annual cost, applying 4 parts to the million of available chlorine to a sand filter effluent flow of 160,000 gal., would be about $924. Capitalized at 5 per cent., this would represent an investment of $18,500.

Marion. The procedure adopted in the chlorine disinfection tests was substantially similar to that followed in the experiments with copper sulphate, but the rate of application of the disinfectant solution was increased to 3 gal. a minute. As the effluents from either the septic tanks or the contact filters could be diverted directly into the effluent sewer, experiments were planned with each of the three grades of effluents, from the sand filters, the contact filters and the septic tanks.

The effluent from the sand filters was first experimented with, and the quantity of chlorine applied during the three runs on the sand filter effluent was on the average 3.8, 3.0 and 1.5 parts to the million. In the first two runs the sterilizing effect of the chlorine was sufficient to remove 98.8 and 99.7 per cent. of the total bacteria, 98.5 and 99.1 per cent. of bacteria developing on lactose-azolitmin agar at 37° C., and 100 per cent. of the acid-forming bacteria, respectively. The conclusion may therefore be drawn that Bacillus coli was not present in the treated effluent. On the third test with a chlorine concentration, on the average of only 1.5 parts to the million, the bacterial removals were 94.3 for total bacteria at 20° C., 99.2 for bacteria developing on lactose-azolitmin agar at 37° C., and 99.9 per cent. for acid-forming bacteria. The average of the platings at 37° C. in the case of the third run contained but one red colony. This, by full determinative tests, was found to be Bacillus coli. No residual chlorine was found in the disinfected sewage.

The effluent from the contact filters contained organic matter of a more putrescible character than did the sand effluent previously studied. The quantity of chlorine applied ranged from a minimum of 1.7 to a maximum of 14.5 on the first run; on the second run, from a minimum of 2.6 to a maximum of 20.4, and on the third run, a minimum of 2 to a maximum of 31.8 parts to the million. The quantity of sewage discharged varied widely at different times during the day, depending upon the amount of sewage held in the filter. At the end of a discharge the rate is very small, and during such periods, of course, the strength of chlorine applied was greatly increased.

The effect of the applied chlorine on the chemical character of the contact-filter effluent is similar to that produced in the sand-filter effluents. The average quantity of chlorine, 2.9 parts to the million, sufficed to remove 97.8 per cent. of the total organisms. The tests for Bacillus coli indicated that the contact-filter effluent contained about 20,000 to the cubic centimeter, but after treatment these organisms usually could not be detected in 0.5 cubic centimeter of the effluent.

In the second run, with an average chlorine application of 5 parts to the million, the reduction of total organisms was 97.6 per cent., that of bacteria developing at 37° C. on lactose-azolitmin agar was 99.5 per cent., and the removal of acid-forming bacteria was 100 per cent. Further, Bacillus coli usually was not found in 0.5 cubic centimeter of the treated effluent, while in the untreated effluent it was found in numbers averaging 15,000 to the cubic centimeter. The total organisms in the treated effluent were 1,600, and the total development at 37° C. was 370 to the cubic centimeter. No red colonies were found during this run.

On the third run, with an average chlorine application of 4.4 parts to the million, the total removal of bacteria developing at 20° C. was 99.8 per cent., the removal of bacteria developing at 37° C. was 99.4 per cent., and the removal of acid-forming bacteria was 99.9 per cent. The red colonies developing in the case of the untreated effluent contained 21,000 organisms to the cubic centimeter, while in the treated effluent only 3 were found. The tests indicated that Bacillus coli usually was not present in 1 cubic centimeter, although found in the untreated effluent approximately 20,000 to the cubic centimeter.

The tests for residual chlorine in the treated effluent were generally negative.

Attention was next directed to the application of chlorine to the effluent from the septic tanks. The addition of approximately 5 parts of chlorine to 1,000,000 parts of septic sewage did not suffice to effect a very material removal of either total bacteria or fermenting organisms. The total bacterial removal ranged from 36 to 88 per cent. A higher concentration of chlorine produced only a slight increase in efficiency. At the highest concentration tested the acid-forming bacteria in the applied sewage were 100,000 to the cubic centimeter and were reduced by the chlorine treatment to 51,000, showing an average reduction of 49 per cent. The indications are that with the quantity of chlorine applied the removal of bacteria is by no means as complete as is desirable. Tests for the presence of residual chlorine in the treated effluent were carried out, but were negative in every instance.

An effort was next made to learn the efficiency of greatly increased amounts of chlorine. Such information would appear to be of considerable importance in connection with the disinfection of hospital sewages at times of epidemics in cases where sedimentation alone is the only permanently available means of treating the crude sewage. To this end six experiments in the chlorine treatment of septic sewage were made, the amount of chemical applied ranging from 7.3 to 48.5 parts to the million. The experiments at these higher concentrations were conducted substantially as those already discussed.

About 25 parts to the million of applied available chlorine were sufficient to remove a substantial proportion of coli-like organisms, although a complete removal of Bacillus coli was not accomplished. In the runs in which the concentration of the applied available chlorine was increased to a maximum average of 48.5 parts to the million the removal of Bacillus coli was found only slightly greater than in the case of the application of 25 parts to the million of available chlorine. In this connection it should be noted that the suspended matter in the septic effluent increased considerably, and this probably in large part explains the low removals obtained with the increased quantity of applied chemical. Observations made during the experiments at Marion emphasize the great effect of the periodic discharge of a septic effluent charged heavily with suspended matters. At such times, no doubt, the absorption of the chlorine is very great, and presumably the organic matters in suspension in the septic effluent destroy a considerable part of the disinfectant added.

The cost of constructing a plant for treating the several effluents studied at the Marion sewage plant may be taken as $151, exclusive of arrangements for supplying water to dissolve the chloride of lime. This estimate allows for continuous treatment at a rate of flow of 600,000 gal. in 24 hours.

The cost of applying 4 parts to the million of available chlorine to the sand filter effluent is $730 annually. The total annual cost, including labor, but excluding the cost of supplying water for preparing the chlorine solution, would be about $1,620, on the basis of an effluent flow of 600,000 gal. daily. Capitalized at per cent., this would represent an investment of $29,000.

The cost of applying 5 parts to the million of available chlorine to the contact filter effluent would be about $2.50 a day, requiring 100 lb. of the chemical. The total annual cost, including labor, but excluding the cost of supplying the water for dissolving the germicide, would be about $1,640. Capitalized at 5 per cent., this would represent an investment of $34,000.

Assuming 25 parts to the million as a fair average figure for the disinfection of the septic effluent, provided the same is at all times free from abnormal amounts of suspended matters, the total annual cost, including labor, would be about $5,300. Capitalized at 5 per cent., this would represent an investment of about $106,000.

In view of the importance attached to chlorine absorption by previous investigators and the fact that a fixed relation between the chlorine and the oxygen consumed, respectively, would be of marked value in the practical control of sterilization with chlorine, it was decided to inquire into the chlorine-oxygen relation for conditions at Lancaster. Especially was this important, since a complete removal of Bacillus coli was obtained by the use of slightly less than 5 parts of chlorine to the million, and also since there was noted the presence of residual chlorine after a three-hour storage of the treated effluent.

It appears that under conditions obtaining in some experiments chlorine up to 7.5 parts to the million would be absorbed from the sewage effluent in about 45 minutes, and that chlorine in concentrations of 10 parts and over would be detected in the treated effluent at the end of four hours. Additional experiments showed entirely different results, however; in one instance, a chlorine concentration of 75 parts to the million could not be detected at the end of one hour.

In continuing at Marion the study of the absorption of chlorine by organic matter and the possible relation between such absorption and the oxygen absorption shown by the standard oxygen-consumed process, there were carried out 48 separate experiments. These experiments dealt with the question of chlorine absorption and used, respectively, sand filter effluent, contact filter effluent, septic sewage and crude sewage, each being prepared at different dilutions by the addition of tap water.

From the results of the studies the following conclusions are drawn:

(1) The ratio of chlorine consumed to oxygen consumed in a five-minute period of contact bears no constant relation to the oxygen consumed by the five-minute boiling method.

(2) The concentration of applied chlorine affects the quantity of chlorine absorbed, the absorption at a concentration of 100 parts to the million being fully double that at 50 parts to the million.

(3) Increasing concentrations of chlorine up to 250 parts to the million increase the quantity of absorbed chlorine very materially, but above this there appears to be very little increased absorption even with a chlorine concentration of 500 parts to the million.

(4) Increasing the period of contact to two hours effects but little increase in the ratio of chlorine consumed to oxygen consumed, except for the higher chlorine concentrations of from 250 to 500 parts to the million.

(5) The actual amount of chlorine absorbed in five minutes by the several liquids tested, under concentrations of chlorine of 50, 100, 250 and 500 parts to the million, ranged as follows: Crude sewage, 24 to 148; septic sewage, 41 to 160; contact filter effluent, 42 to 80, and sand filter effluent, 33 to 68.

(6) The absorption of chlorine apparently is largely dependent upon the organic content of the liquid treated, increasing materially as the oxygen consumed of the effluent increases, but not in a definite ratio.

(7) For the same concentration of applied chlorine the ratio between the chlorine consumed and the oxygen consumed appears to increase as the organic matters decrease.

(8) The readily oxidizable matter in the septic sewage studied apparently causes a rapid absorption of chlorine, increasing the chlorine-oxygen ratio, especially in the case of the lower concentrations.

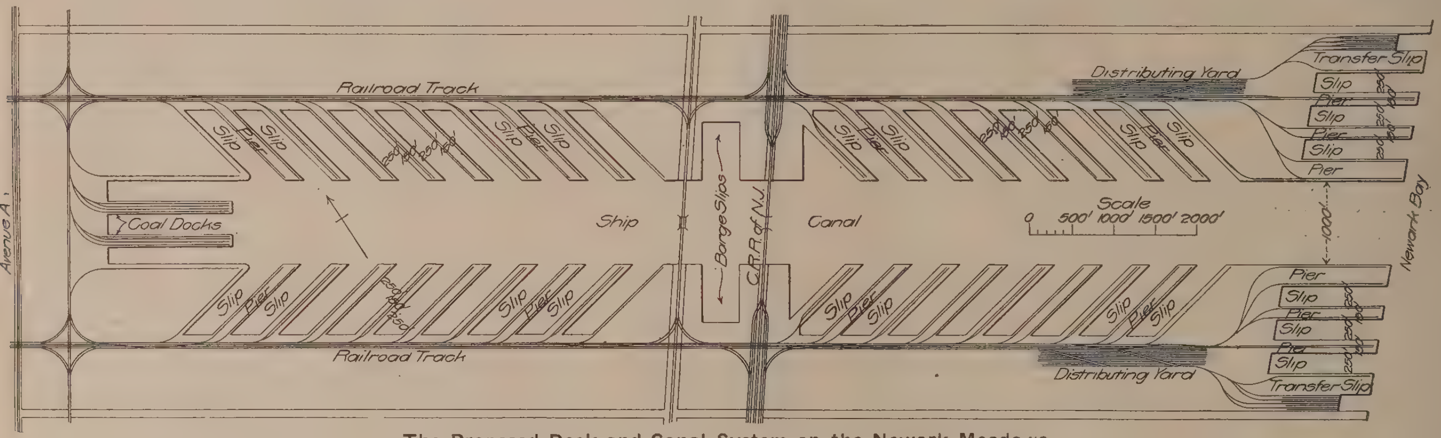
A STRANGE WELL exists at Riverside Park, Logansport, Ind. An 8-in. pipe was first sunk about 80 ft. and inside it a 5-in. pipe was carried down lower. Fresh water from a limestone stratum comes up between the two pipes, while water which tastes and smells strongly of hydrogen sulphide comes up through the 5-in. pipe from a lower stratum. The sulphur water flows at the rate of a gallon a minute from the drinking fountain over the well, while the fresh water flows with a somewhat smaller volume from a pipe about 20 ft. distant. There is a similar well about 15 miles north of Cincinnati, but the latter is non-flowing.

The Proposed Dock System of Newark.

Attention was called some months ago in the Current News Supplement of this journal to the fact that steps were being taken to improve the facilities of the city of Newark for handling water-borne shipments. The project is an old one, but it is only recently that it has taken definite form. The location of the city is such that it can enjoy excellent facilities for shipping at a small expense compared with the benefit to be derived from the cost of the work. The preparation of the plans for the improvements has been entrusted to Mr. James Owen, who has made a study of the subject for many years. The plan he has prepared is shown in the accompanying diagram and the following notes are taken from his report recently submitted to Mr. M. R. Sherrerd, city engineer of Newark.

At the present time one-third of the area of Newark, known as the Meadow Section, is practically undeveloped, although the population on the higher land within the city limits increased from 10,000 to 300,000 during the last century. The manufacturing interests of the city are diversified and there is a large business between the city and New York. The city manufactured in 1905 products to the value of $150,000,000, but its exports by water were only $3,711,364. In the year ending June 30, 1907, the exports had decreased to $1,685,113, although there is no doubt that the total volume of manufactures had increased. Mr. Owen considers that it is probable that $14,000,000 of manufactured products are sent from Newark to New York for transfer into vessels.

The dock facilities of the city of New York are all occupied and an extension of such facilities has become imperative. Various methods of relief have been suggested, but Mr. Owen believes that none of them are equal to the development of docks along the Newark meadows, where railway facilities are far better than on Long Island. By developing the meadows in the manner indicated, Mr. Owen believes that Newark may acomplish the same result that Glasgow obtained in developing the River Clyde. This was changed from a sluggish shallow stream to a broad river by artificial means entirely. The value of the import and export trade of Glasgow during 1905 was over $200,000,000. In view of the desirability of a further accommodation of the trade of Newark itself and the probability of the creation of entirely new business, Mr. Owen believes that the plans submitted form a good, sound business proposition.



The Proposed Dock and Canal System on the Newark Meadows.

The diagram shows the general outline of the works. It is proposed to occupy an area one mile wide and three miles broad. In the center of this tract is the canal itself, 1,000 ft. wide and 30 ft. deep, extending from the dock line on Newark Bay nearly to the westerly end of the tract. On each side of the canal is a system of slips similar in design to the most approved dock construction of this country. The bay front outside the limits of the canal will also be developed in a similar way, and on the westerly end of the canal are a series of slips and piers for coal handling, for domestic and foreign use.

In determining the depth of the canal, the fact that the facilities must be adequate for foreign trade and foreign vessels, make at least 30 ft. desirable. It will accordingly be necessary to dredge a channel in Newark Bay for a distance of about a mile to a point where the 30-ft. depth in that body of water is attainable.

The arrangement of the piers and slips is based on a width of 250 ft. for the slips and 150 ft. for the piers. Each pier in the canal will be 1,200 ft. long. The piers on the bay front in the canal will be 1,500 x 150 ft., and the coal piers will be 1,500 ft. long. On each side of the bay front slips for transfer floats are provided for direct New York trade, or for transfer to railways not having access to the proposed development. It will be noticed that the piers are not laid out at right angles with the canal itself but diagonally, an arrangement which gives an easier access from the piers to the canal. Docks for barge accommodation are also included in the lay-out for the purely local trade from the Passaic and Hackensack Rivers and New York Bay. The total length of the pier frontage is 115,000 ft. or 22 miles, equalling the dock frontage on both sides of the Passaic River from its mouth to Rutherford.

The width of the canal and the proportion of length and width of piers and slips have been settled only after careful consideration of the probable public requirements at this particular location, and from the experience of other places. The width of 1,000 ft. in the canal will give ample room for through communication in the canal and the complete handling of the largest vessel likely to enter it. The length of the piers has been determined from the experience in New York and Brooklyn and elsewhere, and gives room for two or three ordinary vessels, thus giving the greatest rental value for a minimum of expense for construction.

One of the most vital points in the whole plant is the method of communication with the country at large. There are four things to be considered, water communication, which the works are proposed to facilitate; railroad communication in all directions; trolley communication for local car service, and highway facilities for immediate delivery of freight. On the tract in question or immediately adjacent to it are the lines of the Pennsylvania, Lehigh Valley and Central of New Jersey railroads. The plan provides a system of tracks and switches with connection for one or two car tracks on each pier, so that any car at any given point can be taken to any other given point in the system, or be transferred to any of the trunk lines. Two assembly yards have also been designed, and directly connected with them are transfer slips for cars to be hauled away in any direction by water.

Two highway connections are designed as part of the system, one at the west end of the lay-out and one at the center. These highways can be constructed with tracks on them for trolley service.

In addition to the necessary strip of land required for complete access to every point of the development, it is proposed to reserve a strip of land extending nearly 1,000 ft. in width on each side of the piers and slips for future use as may be required, such as for warehouses for storage and for manufacturing plants which may find the facilities favorable for any specific industry. It is believed that this reservation is of the utmost importance in order to complete the system, and the land may be brought to grade by using the material excavated in the main channel in the bay and in the canals and slips.

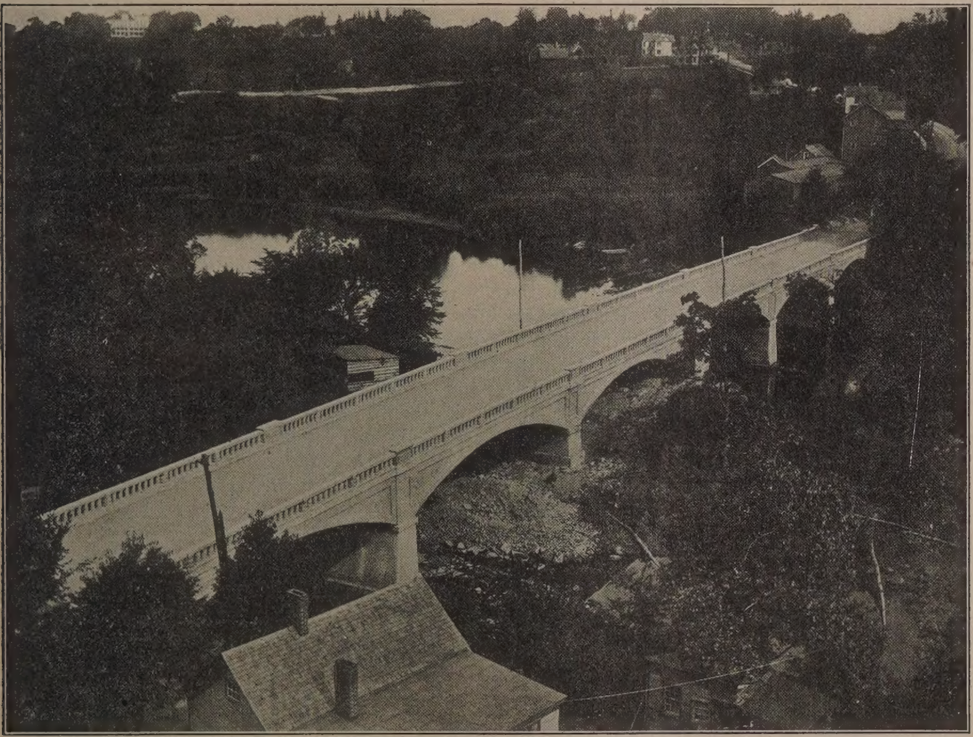
The construction of these works is stated by Mr. Owen to present no difficult engineering problem. The surveys recently made show an average depth of about 10 ft. of black meadow soil and under this a deposit of unknown depth consisting of sand and clay. All the material excavated can be used to advantage in the construction of the piers and wharves, and by a judicious selection of such materials for different requirements great economy can be attained.

Concrete Fly-Wheels are reported in the "Engineer," of London, to be in use at the Zwaartkoppies pumping station of the Rand Water Board, near Johannesburg. The supply is derived from twenty bored wells, 150 to 210 ft. deep, operated in pairs, to balance the working parts of the pumps. The two wells of each pair are about 120 ft. apart. The pumps are of the plunger type, the diameters of the plunger and cylinder being 10 and 14½ in., respectively, and the length of stroke 36 in. Both pumps for each pair of bore holes are driven from one crank shaft through a gearing by an electric motor. On each shaft is an 8,000-lb. 14-ft. flywheel, with a reinforced concrete rim. A cast-iron boss is secured to the shaft, and into this sixteen arms, each made of 4-in. iron pipe, are screwed. Near the outer ends of the arms a ring of ¼-in. iron plate is secured with lock nuts, and around the extreme ends of the arms is fixed a second sheet-iron ring, which forms the periphery of the wheel. The space between the two rings is filled with 1:1½:3 concrete. The concrete rim is reinforced with four ¼-in. rods. The rim alone weighs about 6,000 lb. As the wheels make only 20 r. p. m., their use involves no risk of serious accident, and they are reported to have proved very satisfactory.

A Six-Span Highway Bridge at Catskill, N.Y.

A six-span reinforced concrete highway bridge, over Catskill Creek, having a total length of 450 ft. between the abutments, was finished during the past summer at Catskill, N. Y. The bridge has a clear roadway of 25 ft., a walk of 6 ft., and provision for a single street car track. Each arch has a span of 69 ft. and a rise of 8 ft. 6 in., the thickness at the crown being 16 in., and at the haunches 3 ft. 3 in. Four of the piers are 6 ft. wide, while the center pier is 12 ft. wide. All of them rise about 14 ft. from the footings to the springing line of the arch.

The spandrel walls retain a solidly tamped earth filling on which the roadway is laid. This consists of a slab of concrete paved with Catskill brick. The footwalk has a granolithic finish. The hand rail on each side of the bridge is of simple design, consisting of a rail of concrete cast in place and carried on rock-finish balusters set rather close together.



Six-Span Highway Bridge over Catskill Creek at Catskill, N. Y.

The arch reinforcement consists of twisted steel rods, the longitudinal rods being of 1-in. material on 2-ft. centers, and the transverse rods of ½-in. material on 2-ft. centers. The reinforcement of the hand rail consists of two 1-in. twisted steel rods in the base and one 1-in. rod in the hand rail. The spandrel walls contain no reinforcement except immediately over each pier where two 1-in. twisted rods have been placed to prevent cracking in the railing due to settlement of the piers. The latter have no reinforcement.

The concrete for the arches was a 1:3:5 mixture, made with crushed limestone and trap and Catskill Portland cement. The railings are of a 1:2:4 mixture. All of the concrete was cast in place except the balusters, which were made at the contractors' plant in Hackensack, N. J. A Ransome mixer was used in making all of the concrete at the bridge site.

No especial difficulties were encountered in the construction of the bridge, and though the creek rises rapidly at times, the contractors were fortunate in escaping any serious floods. An old bridge which spanned the creek at this point was removed before beginning the new structure. During construction the traffic was diverted to a bridge lower down on the creek. All of the piers are founded on solid rock.

The centering for the arches was supported upon bents built without sills, the posts being cut of proper length to conform with the rock surface. Six bents were required for each span. They consisted of five 10x10-in. posts cross braced by 3x8-in. timbers. The centering consisted of five framed ribs parallel to the axis of the bridge, and carried upon the bents on wedges. The bottom chords of the centers were of 8x14-in. timbers, while the top chords consisted of three 3x12-in. boards. The framing was of 8x8-in. material. The rib carries 3x9-in. stringers placed transversely on 2-ft. centers and on them was laid longitudinal lagging of 1-in. dressed lumber in 12-ft. lengths. The timber for the centering and bents was obtained from the old bridge.

The work was started in August, 1906, and before cold weather set in the abutments, piers and three of the arches were completed. Work was then suspended during the winter until April of this year, when it was again taken up, the structure being finally finished early in July. The quantity of concrete in the structure is about 4,000 cu. yd., and the total contract price was $43,250.

The bridge was designed and built by the F. R. Long Co., Hackensack, N. J.

An Unusual Boiler Plant is in use at the Moran ship building plant at Seattle, Wash., consisting of a battery of 12 vertical fire-tube boilers arranged in a circle around a refuse burning furnace by which they are heated. The boilers are 5 ft. in diameter by 18 ft. high and the circle is 19 ft. in diameter. The refuse burning furnace has a large conical grate. The space within each boiler constitutes the combustion chamber from which the gases pass down and thence up through the boiler tubes to the chimney, a large conical shell covering all the boiler tops and terminating in an 8 ft. stack. The refuse, consisting of slabs, sawdust and waste material from the saw mill, is fed to the furnace from a large elevated hopper, into which it is delivered by a conveyor from the mill. The entire boiler plant is easily attended by one man on each shift. The saving over the use of coal, at present prices in Seattle, is stated in the "Marine Review" to be over $100 per day.

The Artesian Water Supply of Australia.

By C. O. Burge, M. Inst. C. E.

There is such an extensively utilized artesian area in the United States that it is of interest to learn what is being done in this work in other parts of the world. Recently nearly all the inhabited parts of the Commonwealth of Australia have been blessed with ample rains, and in consequence a boom in production of all kinds has followed. In former times such occurrences there led to the extraordinary delusion that drought would never recur, and few steps were taken to provide against it. Railways were more or less rapidly pushed into the interior, forgetful of the prime necessity of giving them something to do in those almost regularly recurring periods when, as regards the inland districts especially, the rainfall was much below the average, and crops and stock suffered seriously. To any one who has once ridden over these drought-stricken plains of Australia the recollection is vivid indeed. Boundless vistas, with stunted bush and bare brown surface below, and above the prodigal sun and the brassy sky, for months unsoftened by even a fleecy cloud; skeletons of sheep all around the dying flocks, which are scarcely able to reach food or water, if either could be found; the trunks of the shadeless gum trees, gnawed for food by the gaunt rabbit, too weak to run from under the horse's feet; and all this with the deceptive mirage spreading out, in the distance, lakes of visionary water, with trees and rocks reflected in its shining surface—all these are things never to be forgotten.

The want of prevision which has prevailed so much in Australia has never existed in India, the natives to the best of their ability providing irrigation works on an extensive scale in remote ages, and the British adding to them by the magnificent works which, side by side with the construction of railways, have given an ample return for the large capital expenditure incurred. As an instance of what is here stated, New South Wales, the greater part of the area of which is subject to these periodical droughts, has practically done nothing, commensurate with its wants and capabilities, in the conservation of surface water, beyond surveying and reporting, until a few months ago, when a great scheme for the utilization of the Murrumbidgee River waters was decided upon. This will undoubtedly reclaim a large area of possibly drought stricken, though otherwise fertile, land. Victoria, though her needs are not so great, owing to a generally more regular rainfall, has been somewhat more vigorous in the past, but, taken as a whole, irrigation has been exceedingly neglected throughout Australia. The future prospects of the commonwealth, therefore, are all the more hopeful now that some substantial efforts in this direction are being made, showing that if, generally, a prosperous career has, so far, been the characteristic of the Southern Continent of the British Empire, how much more will this be the case under the newly awakened condition of its inhabitants as regards the value of water.

Among these substantial efforts are the utilization of the artesian water which has been going on for some time in Queensland and New South Wales, and, though the quantity of water from bores is insignificant, as compared with that from surface supply, and though it is limited to the artesian area, large as that is, yet a great deal has been done chiefly in the direction of watering stock. An ideal artesian basin is only to be found where the water-bearing strata dip in the middle of the area, outcropping all round at a higher level than that of the surface at the sites of the bores. Most of the artesian basins known throughout the world, however, are not of this ideal character, there being a break in the continuity of the porous outcrop somewhere, leaving a leakage, which more or less seriously draws away some of the supply otherwise released by the bore. The great artesian basin of Australia is of this latter type, the intake beds outcropping along its eastern and northeastern sides only, while the remainder of the water-bearing formation leaks into the Gulf of Carpentaria or is hidden under the superficial deposits forming the plains of the interior of the states.

With a map of Australia before us we can easily trace the boundary of this great area. Beginning at the southwestern coast of the Gulf of Carpentaria, it runs irregularly southward to the 25th parallel of latitude, thence westerly to about 133° east longitude, thence south to the 31st parallel, along which it bears easterly, but with many indentations, to near the town of Dubbo, in New South Wales, which is the southeastern limit. The eastern and northeastern boundary, from which the chief supply comes, is roughly parallel to the east and northeast coast, about 150 miles from it in New South Wales, and over 200 miles in Queensland, joining the coast again about 100 miles from Cape York, on the eastern side of the peninsula of that name.

The greater portions of this area are in Queensland, 376,000 square miles, and in South Australia, 110,000 square miles, but in the latter it is mostly in an undeveloped and unexplored territory, while the smallest portion, 83,000 square miles, included in the area in New South Wales, is a settled, though not populous, district. The area of intake beds is about 50,000 square miles in Queensland, and 18,000 square miles in New South Wales. Victoria and Western Australia are both outside the area. Except for a strip about 100 miles wide on the eastern and northeastern side, the area is within the zone of 20 in. annual rainfall, and further inland of the 10-in. zone, and it is the character of these zones to absorb and evaporate much of the rain falling on the surface. The Murrumbidgee, the Lachlan, Darling and other rivers are much larger in the middle of their course than at their outlet, where they join the Murray, the water spreading out into lagoons between these points and being lost largely by evaporation.

To return, however, to the artesian area. This has, in the opinion of some experts, ocean outlets not only at the extreme north, as shown by the description of the area given above, but also to the great Australian Bight, to the south, but the latter view is disputed, and Professor Gregory, of Melbourne, opposes it. In his recent work, "The Dead Heart of Australia" (1906) he says: "The only available outlet is northward over a rock barrier into the Gulf of Carpentaria, or possibly eastward to the South Pacific. The fact that the main artesian basin has no regular outlet and is enclosed by a rim complete to west and south, and has only a narrow shallow lip to the north, and perhaps another to the east, shows that the deep central waters are old accumulations. The wells are the modern artificial outlets from a vast reservoir, which is almost entirely enclosed, and the waters discharged from it must have been collected during the course of centuries and probably of past millenniums. Nature has stored up a vast but probably a limited supply in a safe underground reservoir. That water, if prudently used, would probably last till Central Australia were so well occupied that it could afford to provide a more costly supply." As to leakage from the basin, Mr. Pittman, the government geologist of New South Wales, points out that any accumulation of water, underground or surface, must eventually become salt, unless it has an outlet, due to dissolution of saline matter from rocks or soil, and that, therefore, all artesian basins affording potable water must have leakage.

A recent interesting and voluminous paper on the artesian resources of New South Wales, by Mr. Percy Allan, M. Inst. C. E., M. Am. Soc. C. E., read at the University of Sydney, and the valuable annual reports of Mr. J. B. Henderson, M. Inst. C. E., hydraulic engineer for the Queensland government, enable fairly up-to-date figures to be given on this subject. The first bore in New South Wales was in 1879 on the Killara Station, between Boweke and Wilcarmia, which, though successful, was on a small scale, being only 140 ft. deep, but the owner of Kerribee Holding, near Bourke, followed with one of 1,073 ft., yielding 350,000 imp. gal. per day. The government started work in 1884, and up to the date of the latest figures there are 412, of which 41 have been failures. Of these bores, 130 have been put down by the government. The deepest bore in the state is that at Dolgelly, near Moree, 4,068 ft. deep, but the finest example, taking the flow into consideration, is the Euraba bore, in the same district, at a depth of 4,005 ft., giving a flow of 1,097,420 imp. gal. per day, the finishing diameter being 6 in. Mr. Allan gives the following average example, occurring at Rowena, near Walgett. This bore was sunk to a depth of 2,669 ft., at a cost of $11,880, having a flow of 924,990 imp. gal. per diem, which, by means of 41 miles of distributing channels, constructed at a cost of $4,051, including headworks, divisors, drops and culverts, waters 55,405 acres. The total cost was about $16,195, the benefit derived, according to experts, being about $1,920 per annum. The rate charged was equivalent to 0.022 cents per 1,000 imp. gal. The temperature of the artesian water at the bore mouth varies from about 78° to 135°, not always according to depth, but exposure to the atmosphere quickly reduces it, as a rule. However, the district being largely in the hottest part of New South Wales, the temperature of the air is occasionally higher than that of the water. The present writer once used, in the hot season, the baths at Moree, supplied by artesian water at 110°, from a depth of 2,793 ft., and could not make up his mind whether the air or the water was the cooler or more refreshing, or, perhaps metaphorically, which was the frying pan and which was the fire.

In Queensland the government was first in the field at Blackall, and there are now over 1,130 bores, of which about 11 per cent. were put down by government. Many inland towns are now supplied with water from artesian bores, among others Blackall, Cunnamulla, Aramae, Charleville and Roma. The deepest bore is that at Bimerah, which was sunk 5,045 ft., but the supply is small, while the aggregate amount of sinking for the whole state is upwards of 225 miles. The highest flow from any single well is 4,000,000 imp. gal. in 24 hours. Trouble, of course, arises from the presence of alkalis in both states, this being, according to Mr. Henderson, inimical to plant life when over 30 grains per imperial gallon are found. The mineral salts in these waters generally exceed those in the artesian supplies of America, but, on the other hand, the soil in the latter, within the districts served, is more impregnated, and the combination is frequently greater than in Australia.

It is, however, generally agreed that, with some exceptions, on account of quantity and quality, artesian water in Australia is not suitable for irrigating crops, except on a very small scale, but immense possibilities are in view from its provision for keeping stock of all kinds in good condition at all times, and in preservation of life in times of drought. A bore with a flow of 1,000,000 imp. gal. per diem, while only capable of properly irrigating some 400 acres, will provide sufficient water for stock purposes over an area of about 80,000 acres. Extending right through New South Wales, in all directions, are strips of country from half to one mile wide, reserved by the government from private sale or use, through which stock travel from one part of the state to another and feed. Where these intersect artesian country, bores are provided at the public expense, there being an average of one bore to 1,280 acres of the reserve. Including these, and summarizing, there are in New South Wales, according to latest figures, 114 successful government bores, serving 2,122,254 acres, and 257 private ones, the scope of which, if in proportion, would bring the total up to 4¾ millions of acres, the stock on which are served by artesian water. In Queensland, whether it is by ill luck or bad management, the proportion of successful to the total number of bores is much less than in New South Wales; 596 constitute the number of the former, these being mostly in private hands. The total daily flow is estimated at nearly 400 million imperial gallons. Though agriculture has been making great strides lately in Australia, the pastoral industries still are, and for many years to come will be, the chief basis of the prosperity of the commonwealth. Hence, it is interesting to know that a still only partially developed adjunct to the unrivaled wool supply of the world which she affords, is available over such a large area as that described in this article.

Book Notes.

The "Proceedings" of the third annual convention of the National Association of Cement Users is a volume of 340 pages of information of the highest value to engineers, architects and contractors. A report of the convention was published in the Current News Supplement of this journal on January 19 of this year, and it is consequently unnecessary to review the contents of the book at any length at this time. It is particularly valuable for the information it gives on the artistic treatment of concrete, waterproofing and concrete block manufacture, although many other subjects are taken up. The association is essentially one for the interchange of information relating to the practical use of concrete, and its "Proceedings" bear witness to this fact throughout. The editing of the volume has been done by the president, Mr. Richard L. Humphrey, who has eliminated irrelevant matter and repetition of ideas with much skill, thereby increasing the value of the contents to the busy reader. (Philadelphia, National Association of Cement Users, Harrison Building; $3.)

About a year ago the Minister of Public Works of France issued a set of regulations concerning the construction of reinforced concrete works. The reprints that have been made of that circular contain many typographical errors and for this reason it is rather gratifying that the first part of the important work entitled "Recueil des Types de Ponts pour Routes en Ciment Armé," by Messrs. N. de Tédesco and Victor Forestier, contains the full text of the circular and the official instructions concerning it. The regulations in question unquestionably form one of the most important indications the engineer has concerning safe design in reinforced concrete, but they are necessarily somewhat vague in many respects, so as to allow the designer an opportunity for meeting individual conditions and following personal inclinations. The object of this work under review is to explain the application of the regulations to the design of highway bridges of 4, 6, 8, 10, 15, 20, 25 and 30 meters span. In the computations for these structures, the authors have endeavored to follow the spirit of the regulations and to utilize those methods of computation which give maximum economy without entailing too elaborate calculations. The book is probably the most complete explanation of the application of such important reinforced concrete regulations that has yet been attempted. In addition, it gives all the details of a large number of computations that cannot fail to be useful to those who desire to study the methods of design recommended by the authors. This study is much facilitated by an atlas of plates giving to a large scale the drawings of the various bridges referred to in the text. These are essentially working drawings and are executed in an excellent manner. (Paris, Ch. Beranger, 15 Rue des Saints-Peres, 25 francs.)

The attention of all interested in the teaching of mathematics in engineering schools is particularly drawn to the first volume of "A Course in Mathematics," by Prof. F. S. Woods and Prof. F. H. Bailey, of the department of mathematics in the Massachusetts Institute of Technology. This volume is the most important American outcome of the deep impression recently made by the advocates of a reform in the methods of teaching mathematics. Such instruction may be viewed from two distinct standpoints. If the purpose of the instruction is to introduce the student to mathematics as a branch of pure science, in which he may later carry on research work, the best method may possibly be different from those adapted to acquainting a prospective engineer with one of the most useful helps science has to offer him. It is generally held to-day that without any sacrifice of accuracy the methods of instructions best adapted for the mathematical classes in a technical school are those which carry forward at the same time various branches. In the old methods of instruction it was customary to finish algebra before taking up analytical geometry, to finish analytical geometry before taking up the calculus and to finish the calculus before beginning mechanics. As a result of this it was only students with good mathematical memories who were able to appreciate as fully as desirable the relations between the various branches. Such a plan is entirely abandoned in this new course, which, it should be stated, was prepared at the invitation of Prof. H. W. Tyler, head of the mathematical department of the Massachusetts Institute of Technology, and has received the benefit of his criticism. In the first volume, which alone has appeared as yet, there is an introductory chapter on methods of elmination, including the use of determinants. The student next takes up the methods of plotting functions, and is thus introduced early in his course to this valuable practical method of understanding an equation. The study of the algebraic polynomical, including the analytic geometry of the straight line, the more important theorems of the theory of equations, and the definition of a derivative comes next. This enables the student to obtain early an introduction to the principles of the calculus, which is particularly desirable. The study of the algebraic function in general is next taken up, and in doing so the student's knowledge of analytic geometry and calculus is enlarged by new applications of the principles previously stated. Simple integrations are also introduced at this time. Curves are taken up and the student is introduced to this interesting portion of analytic geometry without being confused by the idea that it relates solely to conic sections. After this, the study of elementary transcendental functions is begun and finally the year's course closes with a study of the parametric representation of curves, polar co-ordinates and curvature. It will be noticed that no work in three dimensions is taken up in this course, that being deferred for the second year. It has already been stated that the book is primarily for the use of engineering students; it may be questioned, however, whether the student who takes up mathematics as a branch of a liberal education will not find this method of approaching the subject more satisfactory than the traditional one of attacking one branch at a time. The relations between the several branches taught in undergraduate courses is so intimate that it is safe to say only a student of exceptional natural mathematical ability can acquire so good a knowledge by pursuing one branch after another as by taking them up in the way outlined by Professors Woods and Bailey. It should also be stated for the benefit of engineers who wish to review their mathematical studies that this volume will be found an excellent help for the purpose. It is clearly written, well printed and illustrated, and contains a large number of examples which will be particularly helpful, for it is a well-known fact that a thorough comprehension of a mathematical method is only possible after it has been applied in the solution of a well selected set of problems. (Ginn & Co., Boston; mailing price, $2.40.)

A book that should prove instructive to a wide circle of readers is the "Balancing of Engines," by Mr. Archibald Sharp, who has already contributed a paper on certain features of this subject to the "Proceedings" of the Institution of Civil Engineers. Some ten years ago the methods of balancing were mainly of importance to locomotive designers, but since then there is hardly any prime mover in which balancing has not become prominent. When alternating current generators came to be operated in parallel, the balancing of steam engines at once attracted general attention, and during the last two years everybody interested in automobiles knows that the most debated subject is the relative advantages of six and four-cylinder engines, which depend primarily on the balance of the two types. Up to the present time about the only volume discussing the subject in a detailed manner has been one by Prof. W. A. Dalby, and this smaller work by Mr. Sharp is consequently of particular importance. It is much simpler than the book referred to, and employs graphical methods to a greater extent than the work by Prof. Dalby; the difference in the assumptions made at the outset of the two discussions may lead the reader to believe the results in the two treatises are different, although the difference is only apparent. The volume is unusually thorough, beginning with the primary phenonoma of motion and force and the preliminary theorems in mechanics which are essential for a proper understanding of the problems and methods of balancing. The inertia forces of revolving and reciprocating masses, the inertia forces of second and higher orders, and the transverse couples due to connecting rods are discussed at length. Engines with cylinders in different longitudinal planes receive especial attention. The author then takes up in turn the kinetic energy of pistons and connecting rods, the torque on crank shafts, primary and secondary balances, and finally the displacement of engine frames due to unbalanced forces and couples. There is a special chapter on the engines best adapted for various purposes, considered with respect to their balance, and finally the author gives a forecast of the future development of large gas engines. To make the work as useful as possible to students, a series of exercises, with answers in some cases, is appended at the end of most of the chapters, some of these questions being taken from the papers set at the qualifying examinations of the Institution of Civil Engineers. Some portions of the book are entirely new, others are taken from the author's paper previously mentioned, and the author expresses his especial indebtedness to the work by Prof. Dalby. On account of the widespread interest in the subject, the appearance of a book by one who has made such a specialty of it, is particularly timely. (New York, Longmans, Green & Co., $1.75.)

Letters to the Editor.

TEMPERATURES IN BEEHIVE COKE OVENS.

Sir:—Can you refer me to any information on the temperatures in beehive coke ovens, both inside the oven and on the back of the retaining walls? I am interested in the design of a concrete oven and will appreciate any information you can give me on the subject. Yours truly,

E. HORTON JONES.

Dawson, N. Mex., Oct. 9.

[There is very little information available in the usual sources of such data concerning the temperatures of coke ovens. Probably tests to determine them have been made, but they have not been recorded for ready reference. The temperature within a coke oven of the by-product type, as shown by tests reported by Dr. Schniewind in Sydney and Mr. Hilgenstock in Germany, probably does not much exceed 1,800° Fahr. at any time during the coking operation. It does not necessarily follow, however, that this is the maximum temperature in a beehive oven. In the latter the heating gas burns under the arched roof, heats the brickwork of the roof and the heat is reflected upon the charge of coal beneath. Therefore, the temperature of the roof is very probably higher than that of the charge itself. In the same way, in a by-product oven, the gas burns in the flues, heating the coking charge by transmission through the oven walls. The heat in the flues is unquestionably higher than any temperature the coking charge itself will reach.

In a general way, it may be said that the inside of a beehive oven in full operation will be light red to orange in color, though the heat is not always so great as this. Refractory materials of excellent quality are needed for the roof of a beehive oven, but this is particularly because the hot walls are quenched by water from a hose when the coking of a charge is finished, the sudden cooling being very severe upon any quality of fire-brick as may be imagined. Concrete is manifestly bound to fail if used for a lining. Just what is meant in the inquiry by the temperature "on the back of the retaining wall" is a little indefinite. If it means the temperature at the outer surface of the firebrick lining of the oven, this is probably a low red temperature, or even hotter, depending on whether the bricks are exposed to the air or covered with masonry. In conclusion it might be said that inquiry among oven operators shows that the only way of testing a new form of construction is to build a few ovens and operate them regularly.—Editor.]

THE OCEAN PIER AT LONG BEACH, CAL.

Sir:—It is a problem of no mean proportions to build an ocean pier of any considerable length, and one that will endure, on the Pacific coast. In the first place, storms coming from the northwest, west or southwest, sweep full force against the coast, having no bar to encounter. In the next place, these storms are frequently of great violence and roll up tremendous seas against the shore line, and it takes a very solid structure to withstand their force when exposed to it. Again, there are very powerful undertows on the Pacific coast, and there are, therefore, strong submarine forces to be resisted in ocean pier construction, at the same time.

Yet, along the California coast quite a number of piers of this class are maintained. Some are designed for the handling of freight and passengers, while others are mere pleasure wharves located at popular seaside resorts. One of the most substantial and up-to-date piers of the latter class is at Long Beach, a resort that gets the great bulk of its patronage from Los Angeles and contiguous region. It was designed by, and constructed under the supervision of Mr. Howard C. Holmes, of San Francisco.

It is composed of a wharf and a double-decked approach. The wharf is 100x300 ft., while the approach is 1,299 ft. long and 32 ft. wide.

The water at the outer line of the wharf is 30 ft. deep at low tide, and both wharf and approach are supported by reinforced concrete piers, after Mr. Holmes' well-known patent. The longest cylinder pier used on the construction is 56 ft. in length, and the piers generally are driven from 10 to 18 ft. into the ocean bottom, which is composed of sand. They are all 4½ ft. in diameter, and those supporting the wharf proper are placed 16 ft. apart on centers.

The approach is built of bents, 20 ft. on centers, consisting of two 12-in. I-beams for caps, supported by two reinforced concrete cylinder piers. The stringer system supporting the main deck consists of 4x16-in. Oregon pine timbers, on 2-ft. centers, excepting under the line of posts supporting the upper deck, where 12x16-in. sills are placed to support the superstructure. The outside stringers are of 6x16-in. Oregon pine timbers, and these with all of the above-mentioned stringers, are attached to the double I-beam caps, with cross-clip and I-bolt fastenings, thus avoiding boring and framing the stringers. Both sides of the approach are lined with heavy hand rails supported by 6x6-in. posts placed 10 ft. on centers. The middle of the roadway is used for teaming; and there is a walk on either side, 6 ft. wide, for promenading and fishing.

The upper deck of the approach is 21 ft. wide and 13½ ft. between decks. The upper deck is supported by 12x12-in. posts on 10-ft. centers, having 19-ft. spans in the clear. The main cap of the posts consists of 12x16-in. timbers tenoned into the posts. The deck is sheathed with a double layer of cedar planking. The stringer system consists of 3x10-in. Oregon pine timbers, 2 ft. on centers. The outside stringers are composed of 6x10-in. timbers. The hand-rail on either side of the upper deck consists of 4x8-in. timber supported by 6x6-in. posts, 10 ft. on centers.

Ornamental braces from main posts to main caps supporting the upper deck, materially strengthen that part of the structure. The brace is in the form of a bracket built up of 4x4-in. angle irons placed back to back, the whole forming a very rigid brace, and at the same time obstructing the roadway in the minimum. The upper deck is sway-braced longitudinally with 4x10-in. timbers.

In order to make the structure as attractive to the eye as possible, it is painted throughout. The sub-structure is of a deep maroon with cylinder hoops painted black for an agreeable contrast. On the main roadway all railings and exposed woodwork are painted a rich olive green, while the hurricane deck is left dead white. At the end of the pier proper is a pavilion patterned after a Swiss chalet. In this pavilion every afternoon an instrumental concert is given at the expense of the city of Long Beach. Surrounding the pavilion are refreshment booths and space for those who desire to fish from the wharf. The wharf is also arranged for the mooring of vessels of any size.

This wharf has now withstood the fury of the Pacific gales for four years without showing a sign of weakness, although the waves sometimes break to a height of 24 ft., and the sands underlying the sea are at times plowed up to a depth of 13 ft. by the powerful undertow.

Yours truly, H. A. Crafts.

Relations of the Public School to the Industrial Trades.

Sir:—The engineering public is at the present time deeply interested in matters relating to education in industrial lines. The old time apprentice system has been worn threadbare; in fact, it has almost ceased to exist. Modern manufacturing methods tend only to the making of the specialist in machine tool operation, or in hand work. Excessive specialization has thus prevented the development of the all-around mechanic, and what is more vital still, of the broadly experienced, competent manager of men, the foreman or superintendent. Sporadic instances have appeared during the past few years where manufacturers have sought to establish effective means of giving their young employees a more general knowledge of the specific industry than can be obtained through any of the ordinary channels. Privately-maintained trade schools have bent their efforts to supplying the opportunity for those to learn who really want to learn a trade.

The public schools have assuredly been lacking in their ability to cope with the problem. The manual training school has laid the foundations for the engineering professions rather than for the mechanical trades.

With this exception, vocational training has been practically non-existant in the public schools, and even direct preparation therefor has formed a meagre part of the curriculum.

But it is now generally recognized that the concerted effort of the municipality and the commonwealth is necessary to provide what the middle, the so-called working classes, so much need, namely, education in particular trades.

It is not surprising that Massachusetts should be taking the lead in this movement. Through a Commission on Industrial Education, it is working out plans by which vocational schools may be established and maintained at the joint expense of city and state. Evening schools are already operated under these conditions.

But particularly interesting, as indicative of the trend in education, are the changes which are now being made in the school system of Boston. A radical move has been made in the reduction of the elementary school course from nine to eight years. This will provide for an earlier entrance upon industrial training.

There has been a distinct change in the ideals. Teachers are no longer to measure their success by the number of pupils that reach a certain fixed and traditionary standard of scholarship. Success will rather be judged by ability to provide work of such a nature that all of the scholars not grossly indolent can reach a satisfactory standard: To have twenty per cent. of a class fail to pass is full proof either that the work is not adapted to the class, or that the teacher is inefficient, and yet in many classes, the percentage of failure has risen to thirty-five or even forty per cent.

It is boldly asserted by the Superintendent that "if now and then a pupil should fail to do the work, it would perhaps be justifiable to say that he is not qualified to profit from high school instruction, and that he should be excluded from the school; but when twenty-five per cent. of all pupils in the high schools of the city fail to do the work required, a course of exclusion cannot be successfully defended. These pupils are as justified in demanding high school instruction adapted to their needs, as are the pupils who find it possible to do the work now offered."

Consideration is therefore being given as to how the high school needs to be modified in order to make pupils meet the present standards. Investigation has shown that out of two thousand boys seeking employment, nearly fifty per cent. would have remained longer in school could they have been taught even the rudiments of a trade.

Already a Girls' High School of Practical Arts has been established, with a course of study four years in length, with conditions of admission and graduation equivalent to those required in the regular high schools of the city. Its purpose is to give a greater opportunity for development of that type of pupil whose talents lie more in lines of doing and expression than in lines of acquisition.

The High School of Commerce is just entering upon its second year. This is definitely a vocational school, seeking to give the most effective preparation for participation in commercial life.

For many years it has been impossible to admit to the Mechanics' Art High School all of the pupils applying for admission. The facilities are now being largely increased. It is manifest that the ideals of this school will need some adjustment in order that the training may be made more definitely vocational.

It is recognized that efforts to incorporate industrial training in the elementary schools must still be looked upon as experimental. To this end changes are being made in the courses in certain districts under which certain boys will be given a much larger proportion of industrial training than is provided in the regular course.

The evening schools continue to give more or less vocational training. The teachers realize that a great many people are seeking industrial and technical instruction in correspondence schools. In fact, the Director frankly states that "the instruction pamphlets published by some of the correspondence schools on technical subjects are superior to anything I have seen in public school text books."

To rival such instruction in the evening schools, or in day schools devoted to vocational training, would manifestly entail large expenditures for equipment and maintenance. The problem is, however, simplified by the attitude of the state through its Commission on Industrial Education. In accordance with the law, and under the supervision of this Commission, municipalities may be in part reimbursed for such expenditures as they may make for the maintenance of industrial schools. This Board is instructed to consider and report upon the advisability of establishing one or more technical schools or industrial colleges, providing for a three or four years' course of extended training in the working principles of the larger industries of the commonwealth.

The Commission already expresses its belief that for pupils of fourteen or fifteen years of age, four years' instruction might be provided, so that the first two years would cover general shop instruction relative to mathematics, drawing, natural science, and English, and that the work of the last two years, or which could be gradually completed during a longer period in the evenings, or on the part-time system; meaning part of the time in the factory or shop, and part of the time in school during working hours, whether in the same day or at intervals of several days, or even weeks, by pupils who were obliged to go to work at sixteen, should give the shop instruction for particular trades. The Commission intends to provide effectively for evening pupils, and to make every effort to secure the co-operation of employers, to the end that part time courses for apprentices may be established in the proposed schools.

The efforts in Massachusett and other states will be watched with much interest, in contrast to those being made in the trades themselves, under the direct supervision of the employers. It is reasonable to anticipate that eventually the best results will be obtained through a harmonious combination of effort; the public schools laying the foundation, and the respective trades furnishing the superstructure. C. E.

Boston, Nov. 7.

Lighthouse Construction is being conducted under great difficulties at the Ar-Gazeck reef on the French coast near Ushant. The late Eugène Potron left £16,000 toward the construction of this light, which the government undertook to build. During 1904 the swiftness of the currents prevented more than 52 hours' work on the foundation, more than 206 hours in 1905, and more than 152 hours in 1906. During three years, therefore, only 51 days of 8 hours were available for the work.